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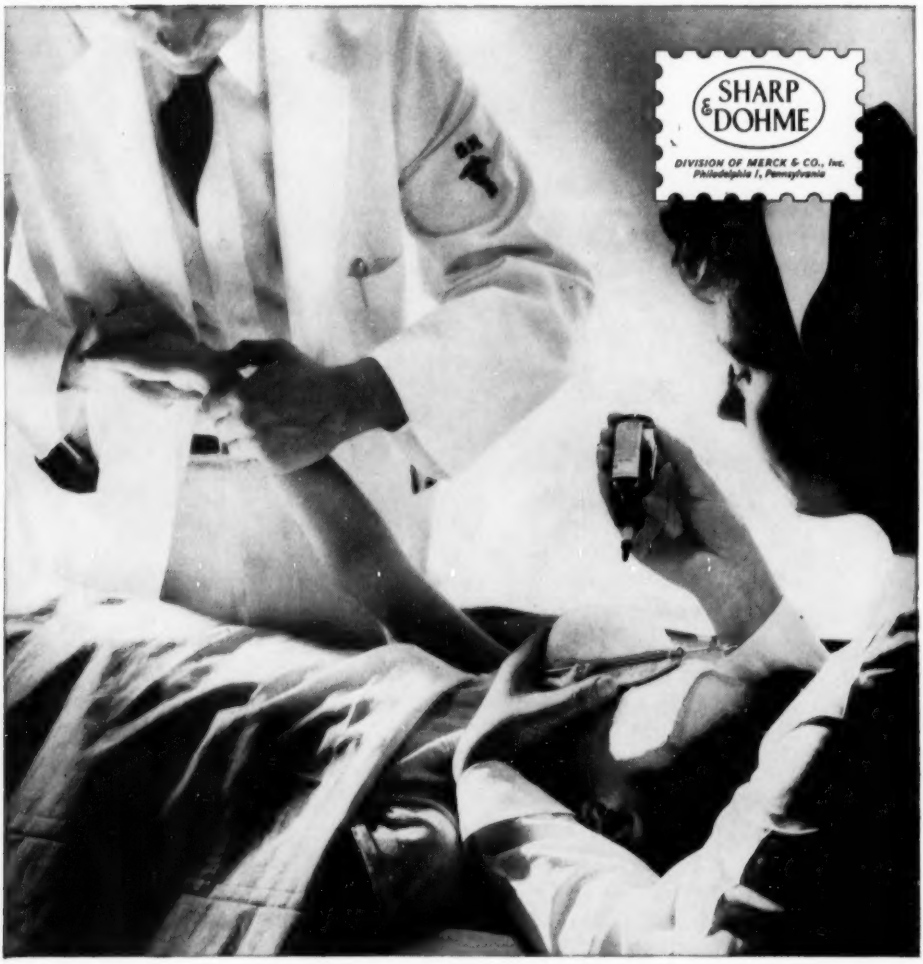

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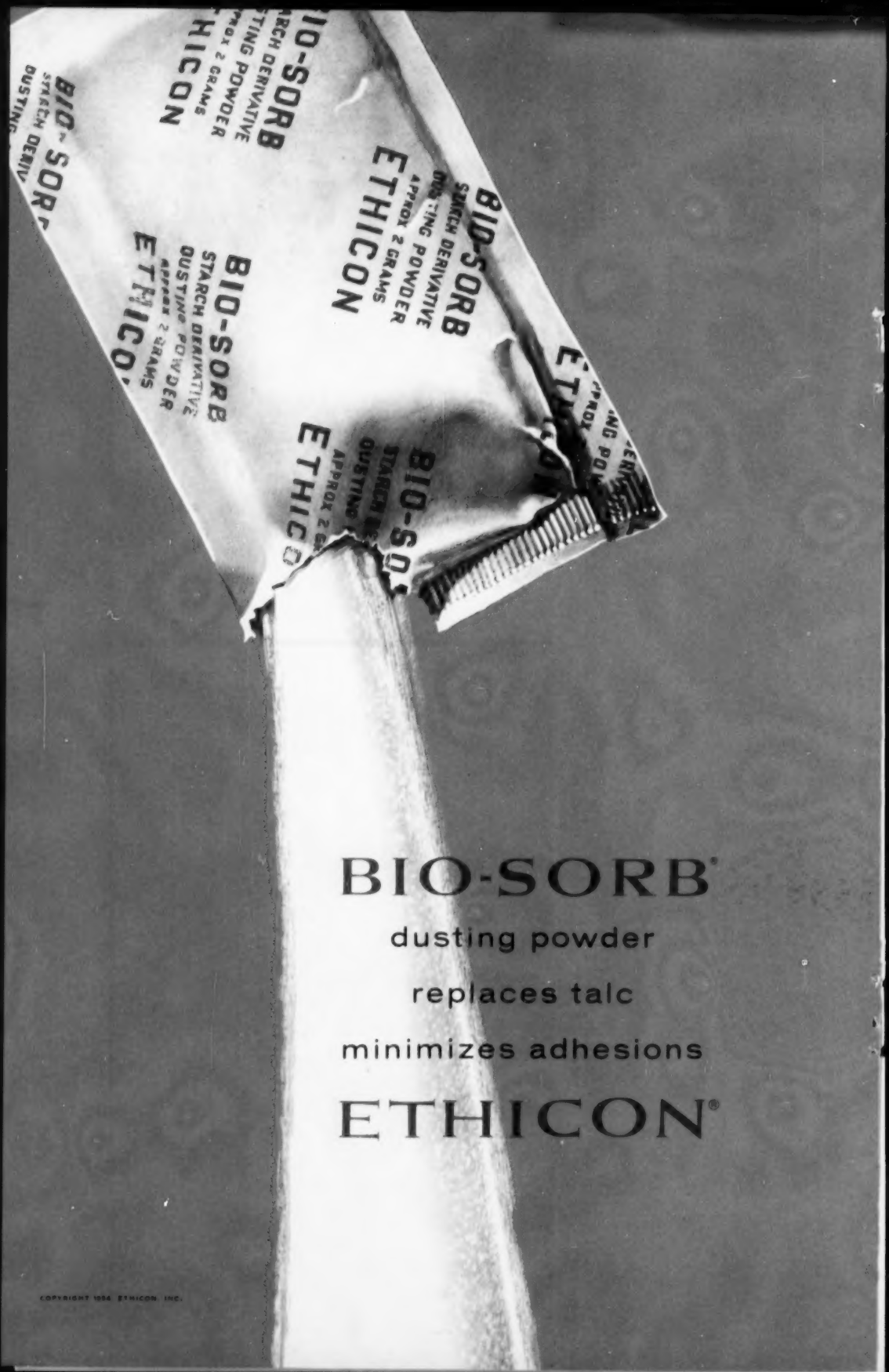
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ARCHIVES OF SURGERY

VOLUME 69 AUGUST 1954 NUMBER 2

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THE HEAD, THE HEART, AND THE HAND

JAMES T. PRIESTLEY, M.D.
ROCHESTER, MINN.

THERE is no doubt that the phenomenal scientific and technical advances which have been made in medicine and surgery since the turn of the century offer the patient of today far greater opportunity for effective treatment and cure of serious disease than could have been tendered him in any former period. These numerous and far-reaching developments, and their social and economic significance, as well as their importance to the health of mankind, need not be enumerated to this audience. Obviously we, as members of a profession, are equipped to do a better job both medically and surgically than at any previous time in history, and I am sure that we all strive to utilize fully the therapeutic advantages which are available to our patients of today.

Granting the significance of this scientific and technical upsurge of the past 50 years, yet have we lost anything of value during this period? Have the remarkable advances in medicine and surgery resulted in emphasis of thought and action so that we are too inclined to look upon our patients only as so many milliequivalents of potassium, so much extracellular fluid, a problem in nitrogen balance, a diagnostic puzzle or a surgical challenge? Such considerations are essential in the present-day care of patients, but do we at times forget that "the patient, not the disease, is the entity"? It might be asked, also, if economic considerations, personal interests, or the rush of busy schedules have made us less mindful than we should be of the human side of our obligations. Has the art of the practice of medicine, which in essence is intelligent understanding, humanitarian interest, and sincere devotion to patients, become eclipsed by these other considerations? Characteristically, we are always looking forward, but perhaps it might be worth while, for a change, to look backward, for among our predecessors were many remarkable men of sterling personal qualities.

At the turn of the century, the typical doctor necessarily relied heavily on information gained through his five senses, which incidentally may suffer today in some of us from the atrophy of disuse. Not being so familiar with biochemistry and physiology as we are, our counterparts of 50 years ago thought more of the patient and less of his constituent parts. They thought not only of the disease which the patient presented but of the patient as a whole, his worries, personal problems, and responsibilities. They were concerned with the patient's happi-

Presidential Address read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 19, 1954.

Section of Surgery, Mayo Clinic and Mayo Foundation. The Mayo Foundation is a part of the Graduate School of the University of Minnesota.

ness as well as with his illness. Their humility was similar to that of Ambrose Paré when he said: "I dressed the wound; God healed him." Their thoughts directed primarily toward service to patients, were unhampered by concern over financial gain. Their patients had no great worry about bills, because, if such were rendered, they were always fair. Not much was heard about lack of medical care for the poor. All knew they would be cared for in their own communities, whether or not they could pay.

The doctor of those days had no need for protective insurance because seldom would anyone think of suing a diligent, respected and loyal friend who gave freely of his time and effort. "Socialized medicine" was an unknown term and would have had few supporters if suggested. Committees on public relations were unknown. Such a need did not exist, for then, as today, each doctor was more intimately engaged in public relations work for the profession as a whole than was anyone else. His job in this regard was well done, although without conscious effort. The doctor, a public-spirited citizen who gave unstintingly of his efforts and energies for his patients and worthy community projects, needed no go-between to interpret him to, or defend him from, the public. Kindness, genuine concern for the patient's welfare, a feeling of responsibility for each individual patient, and evident friendly interest were his well-recognized characteristics. These attributes generated a reciprocal feeling of appreciation and confidence which were part of his greatest assets. The medical profession not only was held in high regard but occupied a position of esteem and affection not awarded many other groups. Although the doctor's income in dollars may have been small, this was compensated for by his returns in devotion and loyalty.

How are things now? One might say that today our patients receive better care than ever before, which is undoubtedly true from the strictly medical and surgical point of view. The advances in medicine and surgery which have occurred during the last several decades are gratifying and thrilling, and I am sure that we all derive a certain amount of satisfaction, whether or not we have carried the ball ourselves, from just being on a team which has won so many victories. The essentiality of research is obvious. It must continue and receive all necessary support. Undergraduate medical education, advancing step by step with growing knowledge in basic as well as clinical fields, offers the student of today finer preparation than at any previous time. Likewise, current opportunities for graduate training never have been surpassed in either quality or quantity. In order not to become too self-satisfied, however, it might be appropriate to look at ourselves and at some of our shortcomings, as, of course, we are not perfect.

I have been unable to determine who first mentioned the essentials of a great surgeon—the head, the heart, and the hand—but I do believe that we should not forget the significance of these attributes. Consideration of the preceding comments makes it apparent, I believe, that the head and the hand aren't doing too badly, or at least they shouldn't be, but what of the heart? Has this been somewhat forgotten? Undoubtedly many of the changes in the practice of medicine and surgery which have occurred during the last 50 years are to a considerable degree the result of changing economic, social, and governmental factors in our own country, as well as of the influence and actions of other countries. These factors, even though beyond our control, need not change our basic ideals as

doctors nor alter the significance of the Hippocratic oath. If we are constantly and honestly guided solely by what is in the best interest of the patient, we will commit no blunders or errors which our abilities permit us to avoid. In essence, we must guard against unfavorable influences from without, and also from within.

One likes to think of a doctor as a person who is motivated by noble aspirations and the desire to serve those in need of his help. Unfortunately, from time to time we all see evidences of motives and practices which are not of noble origin. Increasing economic pressure is responsible for some of them; this, however, constitutes an inadequate reason for being forgetful of the words of Sir Thomas Browne, who said: "No one should approach the temple of science with the soul of a money changer." "Five percenters," chiselers or others given to dishonest practices do not belong in the medical profession.

Years of institutional training and practice may lead the young surgeon to be more concerned with treatment of disease than with treatment of patients. He has little to do with bringing patients to the hospital where he is working, nor is he likely to be particularly concerned with their social, economic, or family problems. If he is not careful, the patient may represent "the common duct stricture in bed 6" rather than Mrs. Thomas, the mother of four children. Almost as bad, in my opinion, is reference to "the case in bed 4." Would any of us like to be known as "a case"? Nor is the senior staff always free of guilt in this regard. The patient may receive little consideration as a person, even when the boss makes rounds, for he may be thinking of teaching, and perhaps of administrative responsibilities, as well as of investigative possibilities. While of necessity there may be some distinction between the ward patient and the private patient, our fundamental duties and responsibilities are identical with respect to both. Actually, of course, the ward patient is frequently more in need of personal consideration than the possessor of a well-filled pocketbook who occupies a large private room.

If some of us are not careful, scientific thoughts may crowd thoughts of the patient too far into the corner. Let's not get so interested in the potassium and chlorides that we forget the patient. Well-directed clinical research is essential, but unnecessary laboratory studies are wasteful and are not in the best interest of the patient. Enthusiastic members of the junior staff may forget this fact unless they are reminded. With specialization developed as it is today, the patient may see a series of specialists, each of whom considers only that segment of the patient's disease in which he is "especially interested." As a result, no one may consider the patient as a whole. In the words of W. J. Mayo, "The patient should be the hub of the wheel and not just a spoke." Lack of personal interest in the patient himself, in comparison with interest in his disease, is not only contrary to our heritage but generates on the part of the public a similar lack of interest in the medical profession. I believe that if all of us were as good ambassadors to the public as were our predecessors of 50 years ago, fewer problems would confront our profession today.

With the laudable efforts which are expended in the laboratory of research, perhaps there are a few of us who are too prone to carry the spirit of research to the bedside or surgical amphitheater. True, surgical progress must be made at some stage by initial efforts in the operating room, but these efforts should not be made lightly, nor until the justification and advisability of a given surgical

innovation have been well based in careful thought, in logical reasoning, and, when possible, on controlled observations in the laboratory. Let us not confuse the operating room in the hospital with the experimental laboratory.

Then, too, the little things, of which there are such an infinite number, are so important, especially to one who is ill and whose thoughts usually are completely absorbed with his own aches, pains, prognosis, family and economic problems. No doubt those of us who are associated with some type of institutional practice are more inclined to be forgetful of the little things than are those in private practice. A few of these might be mentioned. For example, rounds are being made on a given surgical service. A staff, often the size of a basketball team if not of a football team, approaches a patient's bed or enters his room. Interesting (we hope) medical subjects are being discussed. The conversation continues as the patient is approached and then perhaps a junior member reports on the patient's immediate condition. The patient understands these comments only enough to become more alarmed and to wonder what new and dire developments he may expect. Still talking among themselves, the staff departs with scarcely a word addressed to the patient, who, in addition, has had no opportunity to speak for himself or ask questions. Are we making rounds to visit diseases or patients? At other times, just before we arrive the patient may have waited a long time for a nurse to adjust the bedclothes, elevate the head of his bed, apply a new dressing, lower the window shade, turn off the top light, or attend to numerous other details which are important to him as he lies in bed. How are things after we have left, if we are unmindful of such details? Everything is just the way the patient wouldn't like it. He then has another wait to get things in order again. Does such lack of consideration on our part indicate a personal interest in the patient and make him look forward with pleasure to our next visit?

Likewise, it is easy to grow unmindful of the various other discomforts to which patients are subjected, such as multiple and repeated venipunctures (some of which might be avoided with a little planning on our part), the placing of indwelling tubes, the giving of enemas, the application of uncomfortable dressings, the pulling off of adhesive tape, numerous and varied special examinations, and countless other indignities. At times, especially on large services, the patient's family may get a rather poor break. The senior surgeon may feel that he is too busy to talk with the families of all of his patients; yet who is more interested in the patient than his family? Members of the resident staff may avoid making rounds during visiting hours because relatives delay them in the execution of their numerous duties. Would this type of consideration appeal to us if one of us were the relative?

There are, of course, numerous other "little things"—too many to mention at this time. A single personal experience on the other side of the fence serves to sharpen a surgeon's perceptions for a short period of time. Unless we think of the patient, however, and not just his disease, the small things we can do to promote his comfort and peace of mind may go neglected. Adequate rest; genuine concern over his pain, big or little, and appropriate efforts towards its relief; willingness to take time to discuss his problems and illness; encouragement, and more than anything else, evidence of sincere interest in his behalf, all contribute significantly to his favorable progress and reactions, both physical and mental.

Let us not forget that the junior man absorbs from his senior not only his scientific approach, surgical judgment, and details of surgical technic. The junior absorbs also something of the chief's character: his possession of, or deficiency in, fundamental honesty; his kindness or lack of it; his attitude toward patients, rich and poor; his inclination, or not, to establish the patients and their best interests, as well as their comfort, happiness and general welfare, as guideposts to their care, invariably to be followed. Our responsibilities to our juniors are great, and it might be well if we worried more about how much we are doing for them and less about how much they are doing for us.

One word about the financial aspects of medical practice today: There has been much discussion about the high cost of medical and surgical care, a good share of which actually is the high cost of hospitalization. Much, but not all, of this is beyond our control, but it seems only reasonable that we should be vitally interested and do what we can to reduce excessive expense. I refer to our own daily practice. After all, everything that we employ in the care of patients —laboratory tests, x-ray examinations, dressings, sutures, blood for transfusions, instruments, solutions for intravenous administrations, drugs, antibiotics, and all —cost money which someone must pay, and almost always that someone is the patient, in one way or another. We don't pay for these things ourselves, but it might be a good plan if we used them as if we did. My plea in this regard is to be more mindful of expense, for in this way we can contribute at least a little to the control of medical and surgical costs. A good example, I believe, is blood transfusion. Through Red Cross and other blood banks, it has been made almost as easy for most surgeons to order a blood transfusion as an aspirin tablet. The availability, and you might say, abundance, of blood, doesn't mean that it should be used indiscriminately and needlessly. It appears to have become common practice in some areas to administer blood each time a certain operation is performed rather than to consider the needs of the individual patient and the amount of blood lost. To me this seems an unsound practice. This blood costs somebody something, and its preparation requires the time of many persons, before the patient receives it. Then, too, there is always the occasional significant reaction.

Perhaps I might not do better in closing these remarks than to urge us all, and those whom we train, to try diligently to typify the physician described in the often repeated quotation from Stevenson: "There are men and classes of men that stand above the common herd; the soldier, the sailor and the shepherd not infrequently; the artist rarely; rarelier still the clergyman; the physician almost as a rule. He is the flower—such as it is—of our civilization; and when that stage of man is done with and only to be marvelled at in history, he will be thought to have shared as little as any in the defects of the period and most notably exhibited the virtues of the race."

Let us remember that we are not superscientists, on the one hand, nor supermechanics, on the other hand, but doctors taking care of patients with the humanity, honesty, and sincerity of purpose which are our honored heritage.

GASTROJEJUNAL ULCERATION

TILDEN C. EVERSON, M.D., Ph.D.
AND
MAX J. ALLEN, M.D.
CHICAGO

THE DEVELOPMENT of gastrojejunal ulceration following an anastomotic operation for peptic ulcer must obviously be accepted as an indication of unsuccessful surgical treatment of the ulcer diathesis. Ninety patients with gastrojejunal ulceration have been treated at the University of Illinois Research Hospital and the Hines Veterans Administration Hospital during the period 1946-1954, and are the subject of this report. The great majority of these patients had had their initial surgery performed elsewhere. Gastrojejunal ulceration occurred after gastroenterostomy in 46 patients, after partial gastrectomy in 31 patients, and after gastroenterostomy and vagotomy in 13 patients.

It has been long recognized that gastroenterostomy exerts no beneficial effect on the ulcer diathesis, and, hence, gastrojejunal ulceration following the performance of this operation is easily understood. Yet, although both subtotal gastric resection and vagotomy associated with gastroenterostomy are alleged to be effective in treating the ulcer diathesis, gastrojejunal ulceration occurred in this study in 31 patients after subtotal gastric resection and in 13 patients after vagotomy and gastroenterostomy. However, Wangensteen and co-workers * have pointed out that subtotal gastrectomy is effective in preventing histamine-provoked ulceration in experimental animals only if a minimum of 75% of the stomach is resected. (It is true that nutritional impairment after gastrectomy may be greater with resections of this magnitude.) Likewise, the proponents † of vagotomy emphasize that this operation is effective in reducing gastric acidity and controlling the ulcer diathesis only if the vagotomy is complete.

The extent of previous gastric resection was estimated by measuring the surface area of the residual stomach from x-rays available in 20 of the 31 patients who developed gastrojejunal ulceration after gastrectomy. In 18 of the 20 patients the gastric resection was measured to be 50% or less. In the other two patients the resection was measured to be less than 60%. It is true that this method of measurement does not take into account any dilatation or hypertrophy of the residual stomach which may occur between the time of resection and the time of measurement. However, the amount of residual stomach remaining and the rapidity with

Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 19, 1954.

From the Department of Surgery, University of Illinois College of Medicine, Chicago, and the Surgical Service, Veterans Administration Hospital, Hines, Ill.

* References 1 to 3.

† References 4 to 7.

which recurrent ulceration developed in many instances suggest that hypertrophy and dilatation after resection was not an important factor. Likewise, insulin tests suggested that all 13 patients who developed gastrojejunal ulceration after vagotomy and gastroenterostomy had not had complete section of all of the vagus nerves.

MAJOR SYMPTOMS

The major symptoms referable to the gastrojejunal ulceration, as reported by the 90 patients studied, are listed in Table 1. Abdominal pain was the commonest complaint and was reported by 78 patients. This pain in the majority of instances was described as being similar to the ulcer pain present before operation and epigastric in location. The umbilical location of the pain as described in the literature as characteristic of gastrojejunal ulceration was present in only a few instances.

TABLE 1.—*Major Symptoms of Gastrojejunal Ulceration (Ninety Patients)*

Symptom	Patients, No.
Pain	78
Hemorrhage	55
Vomiting	39
Nausea	26
Weight loss	18
Diarrhea	12
Anorexia	3

TABLE 2.—*Time Interval After Surgery to Onset of Symptoms of Gastrojejunal Ulceration*

Mo.	After Gastroenterostomy (46)	After Gastric Resection (31)	After Gastroenterostomy and Vagotomy (13)
0- 6	6	9	6
6-12	10	7	2
12-24	5	6	5
24-36	5	4	..
Over 36	20	5	..

Hemorrhage was a major complaint in approximately 60% of the patients (55 patients). Vomiting was a major complaint in 39 patients, nausea without vomiting in 26 patients. Other less frequent major complaints listed were weight loss, diarrhea, and anorexia.

TIME INTERVAL AFTER SURGERY TO ONSET OF SYMPTOMS

The time intervals after surgery to the onset of symptoms of gastrojejunal ulceration are listed in Table 2. After gastroenterostomy 6 of the 46 patients developed symptoms of gastrojejunal ulceration within six months. Yet the majority of patients in this series did not develop symptoms of gastrojejunal ulceration until at least two years after the performance of the gastroenterostomy. Twenty of the 46 patients did not develop symptoms of gastrojejunal ulceration after gastroenterostomy until more than three years after the operation. Nine of the 31 patients who developed gastrojejunal ulceration after partial gastrectomy had symptoms of ulcer-

ation within six months after surgery. Fifty per cent of the patients developed gastrojejunal ulceration within one year following partial gastrectomy. However, nine patients did not have symptoms of ulceration until more than two years after gastric resection. After gastroenterostomy and vagotomy 6 of the 13 patients who developed gastrojejunal ulceration had symptoms of ulceration within six months of operation. In this small number of cases all patients with gastrojejunal ulceration following gastroenterostomy and vagotomy had symptoms of stomal ulceration within two years of operation.

DIAGNOSIS OF GASTROJEJUNAL ULCERATION

The diagnosis of gastrojejunal ulceration was conclusively established by barium meal x-ray studies in 70 patients (Table 3). In the remaining 20 patients gastroscopy yielded a positive diagnosis in 4 patients; a positive diagnosis was first made at surgery in 9 patients; in 1 patient a positive diagnosis was made at autopsy, and

TABLE 3.—*Diagnosis of Gastrojejunal Ulceration (Ninety Patients)*

	Patients, No.		Patients, No.
X-ray	70	Autopsy	1
Gastroscopy	4	Clinical	6
Surgery	9		

TABLE 4.—*Treatment of Gastrojejunal Ulceration Following Gastroenterostomy (Forty-Six Patients)*

	Vagotomy (15)	Resection (9)	Resection and Vagotomy (1)	Medical (17)	Other Surgical (4)
Satisfactory	12	8	1	7	0
Unsatisfactory	3	1	0	10	4

in 6 patients the diagnosis was based on clinical findings only. The clinical criteria for positive diagnosis in these six patients consisted of characteristic epigastric pain relieved at least temporarily by food or antacids. In these patients x-rays were either negative or equivocal, and gastroscopy was either negative or was not performed because of the patient's refusal to submit to the procedure. None of these six patients with typical clinical findings of gastrojejunal ulceration was submitted to surgery.

TREATMENT

Treatment of Gastrojejunal Ulceration After Gastroenterostomy.—The type of treatment and effectiveness of treatment of gastrojejunal ulceration following gastroenterostomy is shown in Table 4. Fifteen of the 46 patients were treated by vagotomy. This treatment produced a satisfactory result to date in 12 patients. In three of the patients the results were considered unsatisfactory because of persistent or recurrent symptoms of gastrojejunal ulceration. Nine of the 46 patients were treated by subtotal gastrectomy. This treatment to date has been satisfactory in eight patients and unsatisfactory in one. One patient was treated by subtotal gastrectomy and vagotomy with a satisfactory result. Seventeen patients were

treated by medical management consisting of special diets, frequent feedings, antacids, and in some instances administration of methantheline (Banthine) bromide. Such management has to date been considered by us to be satisfactory in 7 patients and unsatisfactory in 10. Our criteria of an unsatisfactory result with medical management has been two or more hospital admissions for ulcer distress while on medical management. To us this would appear to be a liberal allowance; however, we are quite willing to admit that our medical colleagues might not concur in this interpretation of the effectiveness of medical management. The unsatisfactory results of medical management will be discussed in greater detail later. Four patients were treated by surgical procedures other than vagotomy or subtotal gastrectomy. In one patient resection of jejunum and construction of a new gastroenterostomy was performed. In three patients with an associated gastrocolic fistula resection of the fistula was performed. In none of these four patients was a satisfactory result obtained.

TABLE 5.—*Treatment of Gastrojejunal Ulceration Following Gastric Resection (Thirty-One Patients)*

	Vagotomy (12)	Reresection (5)	Medical (14)
Satisfactory	7	3	1
Unsatisfactory	5	2	13

TABLE 6.—*Treatment of Gastrojejunal Ulceration Following Gastroenterostomy and Vagotomy (Thirteen Patients)*

	Resection (5)	Medical (8)
Satisfactory	3	3
Unsatisfactory	2	5

Treatment of Gastrojejunal Ulceration After Partial Gastrectomy.—The type of treatment and effectiveness of treatment of gastrojejunal ulceration following partial gastrectomy is shown in Table 5. Twelve of the 31 patients were treated by vagotomy. This treatment has been satisfactory to date in seven patients and unsatisfactory in five. More extensive gastric resection was utilized as the treatment in five patients who developed gastrojejunal ulceration after an initial gastric resection. This treatment has been satisfactory in three patients and unsatisfactory in two. Medical management of the gastrojejunal ulceration was utilized in 14 patients who developed stomal ulceration after a partial gastrectomy. This treatment has been satisfactory in only 1 patient and unsatisfactory in 13.

Treatment of Gastrojejunal Ulceration After Gastroenterostomy and Vagotomy.—The type of treatment and effectiveness of treatment of gastrojejunal ulceration following gastroenterostomy and vagotomy is shown in Table 6. Subtotal gastric resection was utilized in the treatment of five of the 13 patients who developed gastrojejunal ulceration following gastroenterostomy and vagotomy. This treatment has been satisfactory to date in three of these patients and unsatisfactory in two. Medical management was utilized in eight patients, with a satisfactory result to date in three and an unsatisfactory result in five.

Summary of Treatment.—In the entire series of 90 patients gastrojejunal ulceration was treated by vagotomy in 27 patients (satisfactory result 19 patients and unsatisfactory result 8 patients), by gastric resection in 19 patients (satisfactory result 14 patients and unsatisfactory result 5 patients), by gastric resection and vagotomy in 1 patient (with a satisafactory result to date), by other surgical procedures in 4 patients (with 4 unsatisfactory results) and by medical management in 39 patients (satisfactory result 11 patients and unsatisfactory result 28 patients).

DISCUSSION OF UNSATISFACTORY RESULTS

In six of the eight unsatisfactory results after the performance of vagotomy the unsatisfactory result might be attributed to incomplete section of the vagus nerves. In only two of the eight patients in whom treatment of the gastrojejunal ulceration by vagotomy was classified as unsatisfactory was there evidence by insulin test that the vagotomy was complete. Walters and Chance, however, have reported that many patients with evidence of recurrent ulceration following vagotomy have evidence of complete vagotomy by insulin tests. All eight of these patients reported hemorrhage as a major symptom, and, in addition, four of the patients had abdominal pain, two patients had appreciable weight loss, one patient had nausea and vomiting, and one patient had diarrhea as major symptoms. One patient developed a gastrojejunocolic fistula within 24 hours after a complete abdominal vagotomy.

Four of the eight patients with unsatisfactory results after vagotomy were submitted to subtotal gastrectomy. Two of the patients have to date had satisfactory results after this additional surgical procedure. The follow-up periods of these two patients are 23 months and 41 months. Two patients have had repeated bleeding episodes after subtotal gastric resection. One of these patients died of an exsanguinating hemorrhage 10 months after subtotal gastrectomy. The other patient has had several episodes of bleeding after a subtotal gastric resection (approximately a 65% resection, as measured from the x-ray outline of the residual gastric pouch). Three patients have been treated by medical management after unsuccessful vagotomy. In two of the three patients ulcer symptoms have persisted or recurred under medical management. One patient has become asymptomatic under medical management. One patient has had a resection of a gastrojejunocolic fistula and has been asymptomatic since this operation (10 months). This last patient has evidence of a complete vagotomy by insulin test. There were no operative deaths in the series treated by vagotomy.

In 5 of the 19 patients in whom gastrojejunal ulceration was initially treated by subtotal gastric resection the results were classified as unsatisfactory. One patient died postoperatively of hemorrhage, and four patients had evidence of recurrent ulceration. In one of these four patients the recurrent ulceration followed a resection of less than 25% of the stomach, as measured from x-rays. This patient has been asymptomatic since a further operation in which 78% of the stomach was resected. Another patient has been asymptomatic since the performance of a transthoracic vagotomy. The extent of resection in this patient was calculated from x-rays to be approximately 60%, although the surgeon performing the gastrectomy estimated the resection to be approximately 80%. Two patients who have developed recurrent gastrojejunal ulceration had single episodes of hemorrhage and have been treated satisfactorily by medical management to date. X-rays were not available in these two patients for calculation of the approximate extent of gastrectomy.

In four patients surgical procedures other than gastric resection or vagotomy were performed, with unsatisfactory results in all four patients. One patient developed a recurrent gastrojejunal ulcer after resection of jejunum and formation of a new gastroenterostomy. This patient died on the seventh postoperative day of peritonitis following a subtotal gastrectomy. Three of the patients had associated gastrojejunocolic fistulas and had resection of these fistulas. Two of these patients died postoperatively of hemorrhage. The third patient had recurrence of gastrojejunal ulceration within four months and was treated by medical management, with recurring symptoms of ulceration.

Medical management was utilized as the only method of treatment in 39 of the 90 patients reported on in this study. The medical management was judged to be ineffective in 28 patients and satisfactory in only 11. Two patients in this group died of perforation, two patients died of exsanguinating hemorrhage, and two patients died while on medical management following the development of a gastrojejunocolic fistula.

Of the 28 patients with evidence of recurrent or persistent gastrojejunal ulceration while on medical management, pain was present in 26, hemorrhage in 20, vomiting in 17, weight loss in 7, and diarrhea in 5. Some of these patients have had over 10 hospital admissions for gastrojejunal ulceration while on medical management.

To the surgeon, the continued medical management of gastrojejunal ulceration in the face of persistent or recurrent evidence of ulcer activity does not seem advisable in view of the known greater sensitivity of the jejunal mucosa to gastric acid‡ and the dire consequences, such as gastrojejunocolic fistula, which may result from unsuccessful treatment of gastrojejunal ulceration. Yet it is not difficult to understand the basis for much of the reluctance of the internist or general practitioner to abandon medical management, even though not completely successful, in favor of further surgery. Particularly is this true when stomal ulceration develops after vagotomy and gastroenterostomy or subtotal gastrectomy. The medical men feel, perhaps, that surgery has been given an opportunity to cure the ulcer diathesis and has proved unsuccessful. They are unwilling to recommend surgery again when an initial operation which is supposedly effective in treating the ulcer diathesis has failed. However, as shown in this study, gastrojejunal ulceration has developed because surgery has been inadequate; the vagotomy has been incomplete, or the gastric resection has been less than the recommended 75 to 80% to prevent recurrent ulceration. While it is possible that gastrojejunal ulceration may sometimes develop after a complete vagotomy or a 75 to 80% resection, the incidence of such ulceration, particularly after high gastric resection, might be expected to be exceedingly low. Likewise, while it is true that major surgery is not without a mortality rate, the finding of 6 deaths in 39 patients treated by medical management is appreciably higher than might be expected from surgery performed by competent surgeons on reasonably good-risk patients.

In light of the not inconsiderable mortality and morbidity associated with medical management of gastrojejunal ulceration, it would seem rational from the surgeon's standpoint to recommend surgery in all reasonably good-risk patients in whom gastrojejunal ulceration persists or recurs under good medical management.

‡ References 9 and 10.

FOLLOW-UP OF SATISFACTORY RESULTS

In 45 of the 90 patients with gastrojejunal ulceration, definitive treatment of the ulceration was considered to be satisfactory. The time intervals between treatment of the stomal ulceration and the last follow-up in patients with a satisfactory result to date are shown in Table 7. In 7 of the 45 patients the follow-up period was less than six months. However, in 20 of the patients the follow-up period was two years or more. It is, of course, possible that symptoms of gastrojejunal ulceration may yet become evident in some of these patients, particularly in those with a short follow-up period.

TABLE 7.—*Time Interval After Satisfactory Treatment of Gastrojejunal Ulceration*

	Vagotomy (12)	Resection (8)	Vagotomy and Resection (1)	Medical (7)
Gastrojejunal Ulceration After Gastroenterostomy				
0-6 mo.	1	0	0	0
6-12 mo.	4	2	0	0
12-18 mo.	0	3	0	4
18-24 mo.	0	1	0	1
24-36 mo.	2	1	1	1
Over 36 mo.	5 *	1 †	0	1 ‡

	Vagotomy (7)	Reresection (3)	Medical (1)
Gastrojejunal Ulceration After Subtotal Gastrectomy			
0-6 mo.	3	1	0
6-12 mo.	0	0	1
12-18 mo.	1	0	0
24-36 mo.	2	1	0
Over 36 mo.	1 §	1 ‖	0

	Resection (3)	Medical (3)
Gastrojejunal Ulceration After Gastroenterostomy and Vagotomy		
0-6 mo.	2	0
12-18 mo.	0	1
24-36 mo.	1	2

* Follow-up periods for these five patients are 42, 50, 68, 70, and 72 months, respectively.
† Follow-up period 84 months.
‡ Follow-up period 37 months.
§ Follow-up period 72 months.
‖ Follow-up period 42 months.

SUMMARY AND CONCLUSIONS

Ninety patients with gastrojejunal ulceration have been treated at the University of Illinois Research Hospital and the Hines Veterans Administration Hospital during the period 1946-1954.

Gastrojejunal ulceration occurred after gastroenterostomy in 46 patients, after partial gastrectomy in 31 patients, and after gastroenterostomy and vagotomy in 13 patients. Estimation of the extent of previous gastric resection by measuring the surface area of the residual stomach from available x-rays in patients who developed gastrojejunal ulceration after gastrectomy indicated that gastric resections were less than the recommended 75 to 80% in all patients so measured. Likewise, insulin tests suggested that all 13 patients who developed gastrojejunal ulceration after vagotomy had not had complete section of the vagus nerves.

In the series of 90 patients, gastrojejunal ulceration was treated by vagotomy in 27 (satisfactory result 19 patients, and unsatisfactory result, 8 patients); by

gastric resection in 19 patients (satisfactory result 14 patients, and unsatisfactory result, 5 patients); by other surgical procedures, in 4 patients (with 4 unsatisfactory results), and by medical management in 39 patients (satisfactory result 11 patients, and unsatisfactory result, 28 patients).

In only two of the eight patients in whom treatment of the gastrojejunal ulceration by vagotomy was classified as unsatisfactory was there evidence of complete vagotomy by insulin tests. One of the five patients in whom the treatment of the gastrojejunal ulceration by gastric resection was unsatisfactory died postoperatively of hemorrhage; in two of the patients the resection was inadequate (25 and 60%), and in the other two patients x-rays were not available for measurement of the residual stomach area.

Medical management of gastrojejunal ulceration was unsatisfactory in the majority of patients in whom it was used, and there were 6 deaths in 39 patients treated by medical management.

The occurrence and recurrence of gastrojejunal ulceration is directly related to inadequate surgical treatment of the ulcer diathesis. High gastric resection (75 to 80%) or complete vagotomy will be effective in preventing or healing gastrojejunal ulceration in the great majority of cases.

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FURTHER EXPERIMENTAL OBSERVATIONS ON FATE OF BURIED CUTIS AND FULL-THICKNESS SKIN GRAFTS

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AND
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OMAHA

UNTIL 1939, when Uihlein [1] first reported his observations while in Germany, buried cutis and full-thickness skin grafts were practically unknown in the United States. Cannaday * then became interested in cutis and published several reports on the clinical application of this material. Since then, numerous articles have been written on the subject, including both the clinical and experimental aspects.†

One of us [8] (S. A. S.), in 1950, reported his experimental observations on the effect of tension in buried cutis grafts. The results of this work indicated that the residual epithelial elements in cutis, i. e., sebaceous glands and hair follicles, degenerated and disappeared if the material was sutured in place under tension. Our clinical application of this principle has resulted in no evidence of cyst or epithelial pearl formation.

Gordon [9] reported his results with frozen cutis in 1952. With the use of rabbits, peritoneal defects were replaced with dermis which had been alternately frozen and thawed three times. His results indicated that rapid freezing destroyed the residual epithelial cells, preventing the possibility of undesired cyst formation. These observations were verified by the findings of Allgöwer and Blocker,[10] and by Keeley, Gomez, and Brown,[11] who studied the possibility of storing split-thickness skin grafts by freezing and dehydration. They found that the viability of the epithelial elements diminished with the decrease in temperature and duration of storage.

In the discussion of Gordon's paper, Johnston ‡ suggested the possibility of lyophilizing and freezing cutis in an effort to destroy the epithelial elements. Gordon also stated that he was doing further work in the use of frozen cutis as a homograft. As this work was already in progress in our laboratory, this additional interest in the subject indicated that our studies might prove valuable.

PURPOSE OF STUDY

Our objectives were as follows: first, to verify and amplify the observations of Gordon [9] that the epithelial elements of cutis and full-thickness skin were destroyed

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* References 2 and 3.

† References 4 to 7.

‡ Johnston, C. G., in discussion on Gordon.[9]

by freezing. Second, we sought to determine the effect of storage of frozen and lyophilized cutis and skin on the viability of its fibrous elements. Third, we sought to determine the viability of the fibrous elements of cutis and skin when used as buried homografts.

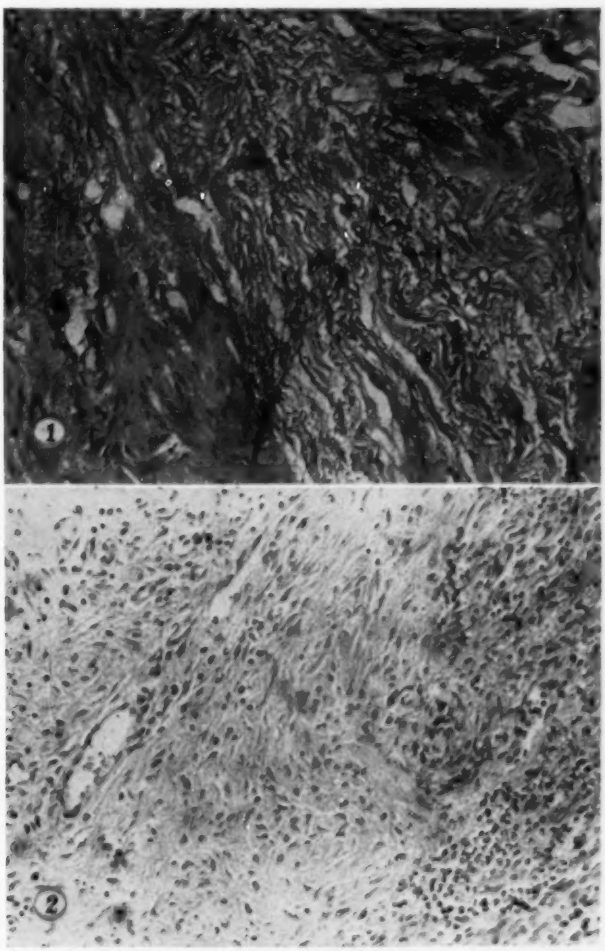

Fig. 1.—Necrosis of lyophilized cutis autograft.

Fig. 2.—Frozen full-thickness skin homograft. Graft junction at right lower corner. Excellent fibrous infiltration.

METHODS

Experiments were carried out on mongrel dogs. The abdomen was shaved and surgically prepared, with the animal under intravenous pentobarbital (Nembutal) anesthesia.

1. *Untreated Homografts* (two cutis, two full-thickness skin).—Two dogs were anesthetized simultaneously. Cutis and full-thickness skin patches were removed and transferred from one dog to the other and sutured into defects of the external rectus sheath. Specimens were removed for study three months after implantation.

2. *Frozen and Stored Homografts* (two cutis and two full-thickness skin).—Cutis and full-thickness skin patches were removed, placed in sterile glass containers, and rapidly frozen at

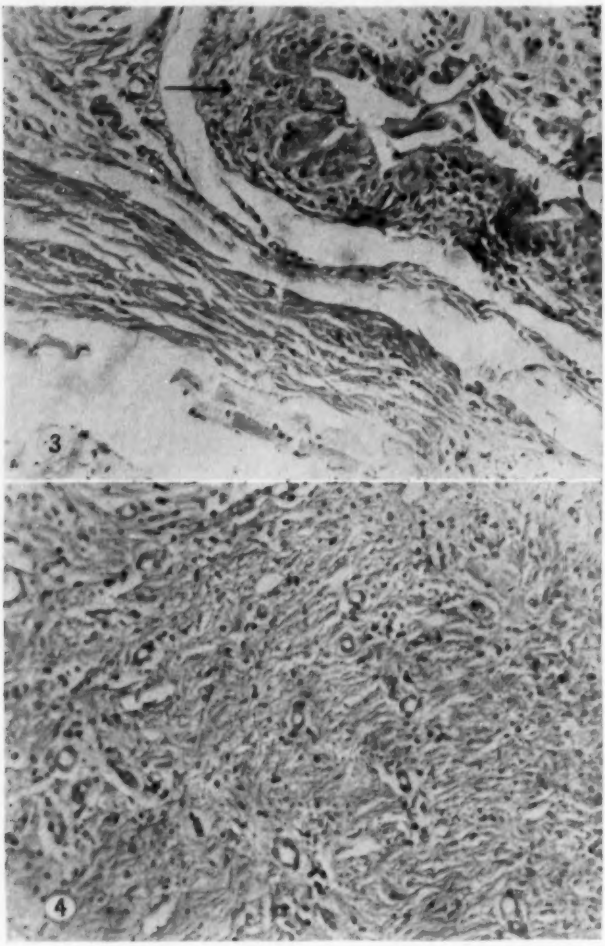

Fig. 3.—Lyophilized cutis autograft. Degenerating epithelial elements indicated by arrow.

Fig. 4.—Frozen cutis autograft. Note the abundance of capillaries.

— 30 C. They were stored in the freezer for one week. Before transplantation, the grafts were allowed to thaw at room temperature for at least one hour. They were then sutured into rectus sheath and peritoneal defects in the recipient animal. Specimens were removed for study one and two months after implantation.

3. *Lyophilized and Stored Homografts* (two cutis and two full-thickness skin).—Cutis and full-thickness skin patches were removed, placed in sterile glass tubes, and immediately lyophilized. The lyophilized patches were then stored for one week at — 30 C. They were then reconstituted in isotonic sodium chloride solution and sutured into peritoneal defects as autografts and homografts. Specimens were removed for study two weeks after implantation.

RESULTS

All wounds healed per primam. Several rectus sheath wounds developed foreign-body reactions which upon microscopic section proved to be probable contamination reaction around the nonabsorbable surgical (silk) suture material. No evidence of relaxation or herniation of the abdominal-wall defects which had been repaired with the experimental material was noted.

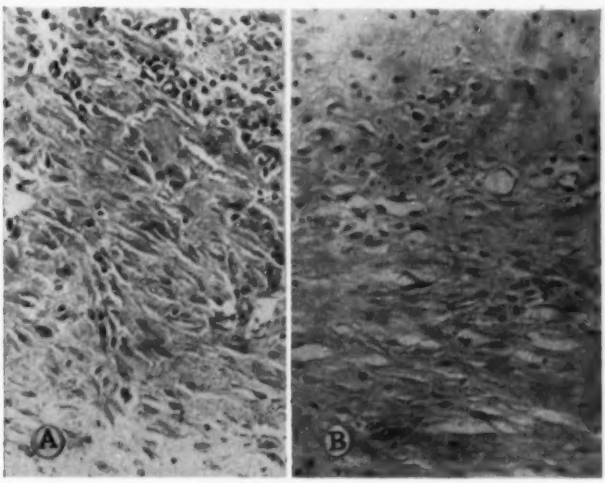

Fig. 5.—*A*, frozen cutis homograft. *B*, lyophilized cutis homograft.

Fourteen separate grafts were implanted in four animals. Only one graft (lyophilized cutis autograft) showed evidence of necrosis or possibility of failure (Fig. 1). All other specimens showed evidence of viability of fibrous elements (Fig. 2).

Residual epithelial elements were observed in only one graft (lyophilized cutis autograft). Although this graft had been implanted only 16 days, the epithelial elements appeared nonviable, as based upon cytologic study and staining reactions in the paraffin-prepared tissue section (Fig. 3).

All specimens were observed to create a profuse vascular response consisting of healthy granulation tissue and invasion of capillaries into the implanted material and the surrounding tissue. The vascular response in itself seemed to be conducive to rapid healing and optimum tissue repair (Fig. 4). The duration of storage evidently produced no difference in viability and adaptability of the implanted material.

Little difference could be noted between autografts and homografts. No histologic difference between frozen and lyophilized material could be detected (Fig. 5). The degeneration and death of epithelial elements commonly observed in split-thickness homografts in skin defects in burns occurs similarly in buried homografts, but the fibrous and collagenous elements remain alive. It might be presumed that cutis and full-thickness skin might be better used as buried homografts than autografts, particularly if used as a fresh graft.

SUMMARY AND CONCLUSIONS

Rapid freezing and lyophilization of cutis and full-thickness skin destroys all epithelial elements, leaving the collagenous and fibrous elements viable when used as buried implanted grafted material. The collagenous and fibrous elements remain viable either as autografts or homografts. Duration of storage of material seems to have no effects upon its viability.

This experimental evidence indicates the possibility of the use of this material in many fields. It has already proved its worth in large fascial defects.

As a stored homograft, its use could be applied to the field of congenital body-wall defects, such as absence of the hemidiaphragm and omphalocele and many others.

DISCUSSION

DR. STUART GORDON, Toronto, Canada: As Dr. Swenson stated, we told you two years ago that we were continuing this work of transplanting treated dermis grafts, and the work we had done up until two years ago was on autogenous grafts. We have repeated it, as he has, with the use of homografts that have been frozen.

Our results, in the gross, are just as satisfactory as they were with autogenous grafts, but we are having very great difficulty histologically tracing what has actually happened to the tissue that we have transplanted. For that reason we have not reported anything on that particular work.

I agree with Dr. Swenson that in this type of tissue, that is, treated dermis grafts, in which the epithelial elements have been destroyed, we have a tissue that will be of real value in repairing defects of the abdominal wall, in reinforcing suture lines, in vessels, and in the treatment of aneurysms, because the tissue is elastic.

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ESOPHAGEAL MOTILITY IN CARDIOSPASM

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IN THE year 1674, Willis [19] encountered a patient with nonorganic obstruction of the lower esophagus and fashioned for his use a whalebone rod capped with a pad of sponge. With this crude instrument the patient successfully forced food into his stomach for a 15-year period. Although the condition was not called such, this report probably represents the first recorded case of cardiospasm. Mikulicz [19] in 1882 discredited the then-existing terminology "primary esophageal dilatation" and postulated that the syndrome was due to functional cardiospasm. This concept remained unchallenged until Hertz [11] in 1914 introduced the term achalasia, which was suggested to him by Sir Cooper Perry. This term was based on the belief that the region of the cardioesophageal junction failed to receive a relaxing neurogenic stimulus. During the years 1926 [26] and 1927,[27] initial pathologic observations involving a deficiency and degeneration of Auerbach's plexus appeared in the literature.

Physiological as contrasted to the previous anatomical investigations were introduced in 1911.[4] A recording balloon was utilized in studying cardioesophageal function. Experimentally, high division of the vagi * or overstimulation of the vagi to the point of fatigue [28] was found to produce esophageal dilatation accompanied by functional obstruction at the cardioesophageal junction. One of the original applications of motility studies to human esophageal physiology was made by Payne and Poulton [23] in 1923. The credit for applying this means of investigation to patients with cardiospasm rests with Puppel, who published his initial studies in 1949.[24]

The investigative observations in our presentation were obtained by using a modification of this technique. Initial observations on patients with cardiospasm were begun in 1951. Since then a series of normal patients has also been studied to establish the range of normal esophageal motility patterns. In addition, several patients with different types of nonmalignant esophageal disease were included to broaden the observations. A group of persons with moderately advanced cardiospasm were studied before and after the performance of a cardioesophageal myotomy or Heller-Zaaijer operation. The latter observations have produced significant findings.

METHOD

Previous to this study a single balloon recording system had been utilized. It was felt that a more accurate record of esophageal motility might be obtained by using three simultaneously recording systems at different esophageal levels. This technique

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Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 19, 1954.

* References 12 and 15.

would allow observation and graphic recording of the coordination or lack thereof as well as the frequency and amplitude of contractions at three differing esophageal levels. Three latex rubber balloons which will each hold 20 cc. of air without forced distention are individually connected to bromoform manometers. The balloons are equally spaced over a 25 cm. segment of Levin tube. In this manner, roughly each one-third of the esophagus is represented in the tracing. (See Fig. 1). A continuous recording is made through independent ink writers on a slowly moving continuous kymograph. (See Fig. 2.) More delicate recording systems were initially tried but were discarded because of the undesirable interference of cardiac and minor respira-

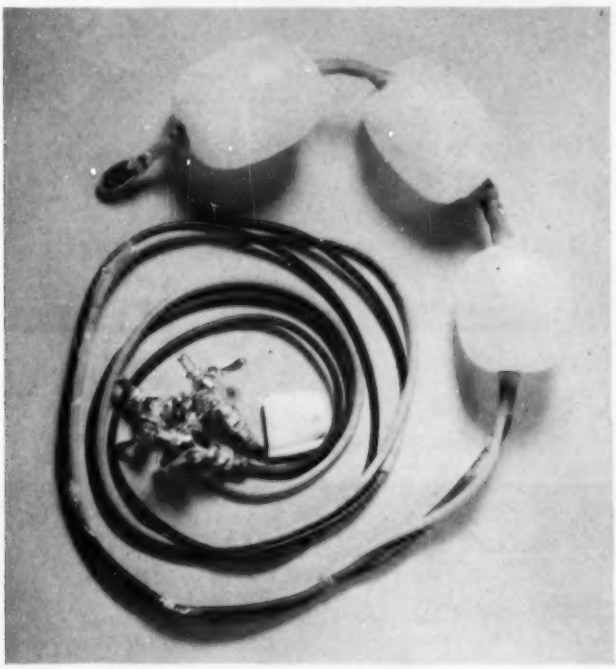

Fig. 1.—Recording system, showing three independent balloons, each filled with 20 cc. of air.

tory movements. The observer is enabled to note visually the coordination of esophageal contractions at three levels. The balloon system is placed fluoroscopically, a radiopaque metal tip with its lowest point at the cardioesophageal junction being utilized. (See Fig. 3.) Examinations are carried out in the fasting state with the patient lying supine. An initial period of observation is maintained for 20 to 30 minutes to allow adjustment of the esophagus to the balloons, which are each inflated with 20 cc. of air. Parasympathomimetic stimulation is initiated by the administration of 5 mg. of bethanechol chloride (Urecholine Chloride) subcutaneously. Allergic states, especially asthma, are considered contraindications to its administration. The effects of atropinization have been studied in a few patients.

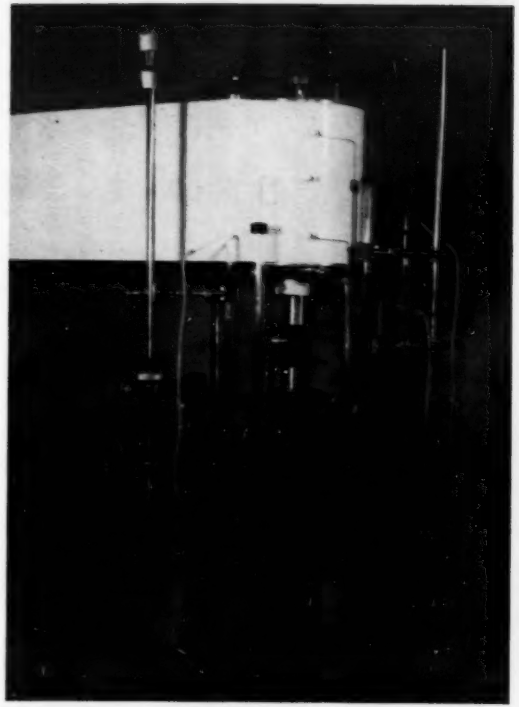

Fig. 2.—Long kymograph showing three independent ink writers supported by bromoform U-tube manometers.

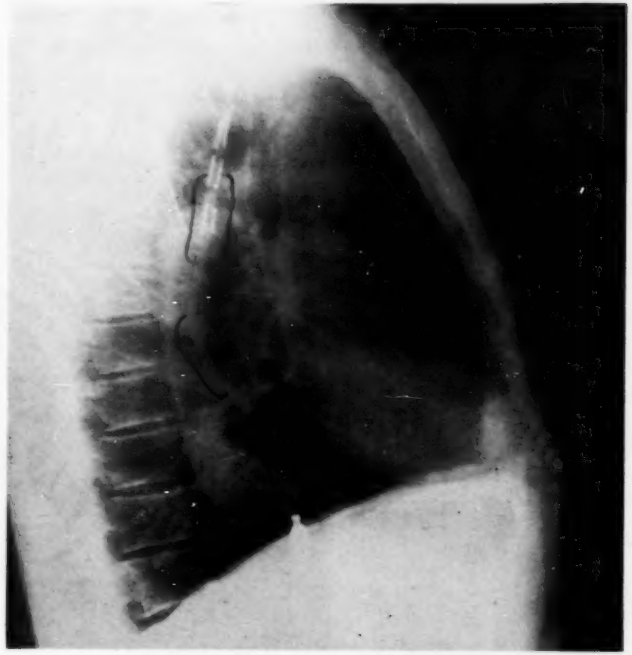

Fig. 3.—Retouched roentgenogram showing approximate position of inflated balloons. Most cephalad balloon actually lies beyond inferior pharyngeal constrictor.

RESULTS

Nine patients hospitalized with nonesophageal disease served as controls to establish a range of normal esophageal motility patterns. Analysis of their records revealed a moderately varying pattern of resting contractions but fairly consistent frequency and amplitude. Three to nine significant contractions per minute occurred, with an average of six per minute. (See Fig. 4.) The amplitude of contractions

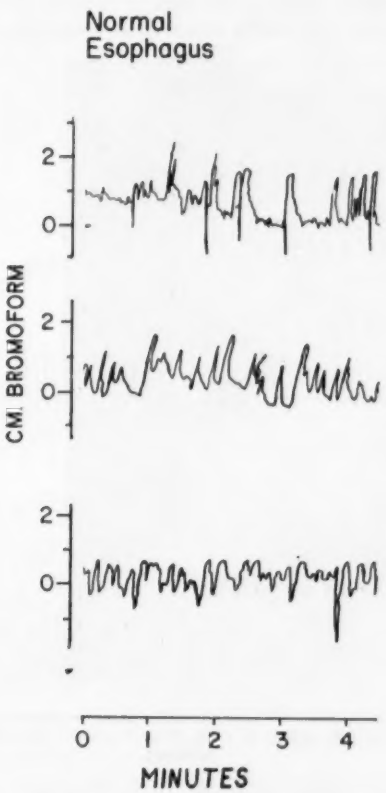

Fig. 4.—Example of normal esophageal motility pattern.

TABLE 1.—*Summary of Initial Observations*

	Before Bethanecol				After Bethanechol			
		Amplitude †				Amplitude †		
	Frequency *	Upper	Middle	Lower	Frequency *	Upper	Middle	Lower
Normal (9)	6.2	2.0	1.5	2.0	6.0	2.0	1.5	1.5
Cardiospasm (4) ‡	0-2	0-1	0-1	0-1	0-7	0-3	0-3	0-3
Nonobstructive dilatation (1)	7	1.5	3.0	1.5	Not done	Not done	Not done	Not done
Regurgitation esophagitis (1)	4	2.5	2.0	8.0	6	2.0	2.5	8.0

* Contractions per minute.
† In centimeters of bromoform averaged from 3 balloons.
‡ The contractions recorded in this group were observed in only 1 of the 4 patients (E. T.).

measured on the kymographic tracings varied from 1 to 5 cm. of bromoform, with an average of 2.5 cm. Bethanechol did not significantly alter the frequency or amplitude of contractions in the control group. (See Table 1.) Similar observations have been made by Puppel,[25] using a single balloon system. Esophageal tone was unaltered. Pain was not experienced when the balloons were filled with the 20 cc. of air. Symptoms due to vagal stimulation 15 to 20 minutes after the administration of 5 mg. of bethanechol were noted in four of the nine patients. These symptoms were manifested by abdominal cramps, nausea, and urge to urinate. The descending course of the normal peristaltic wave was readily observed as it travelled past the three record-

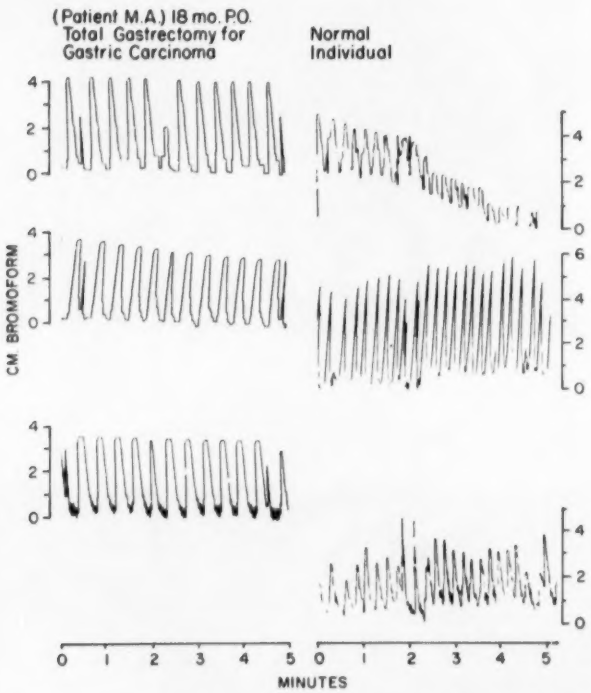

Fig. 5.—Motility pattern showing no significant alteration from normal after removal of sympathetic supply entering cardioesophageal area via left gastric artery. Left tracings, from patient N. A. 18 months after total gastrectomy for gastric carcinoma; right tracings, from a normal person.

ing balloons. This situation proved to be one of the advantages of utilizing multiple independent balloons. An incidental observation was made on a patient previously subjected to a total gastrectomy. The portion of the sympathetic supply to the lower esophagus entering via the left gastric artery had been destroyed by the surgical procedure. This type of autonomic denervation failed to alter the lower esophageal motility pattern from normal. (See Fig. 5.) Observations were made on one patient with severe acid peptic regurgitation esophagitis. This patient had not undergone surgery prior to the examination. Unusually vigorous contractions measuring

6 to 8 cm. of bromoform were recorded from the lower one-third of the esophagus. (See Fig. 6.) This interesting patient also had a gastric ulcer. Gastric analysis did not reveal hyperacidity.

Five patients with varying degrees of cardiospasm were studied preoperatively. Four of these were subjected to motility studies after cardioesophageal myotomy. The disorganized pattern of esophageal contractions occurring in this disease was readily observed and graphically recorded. In the moderately advanced preoperative

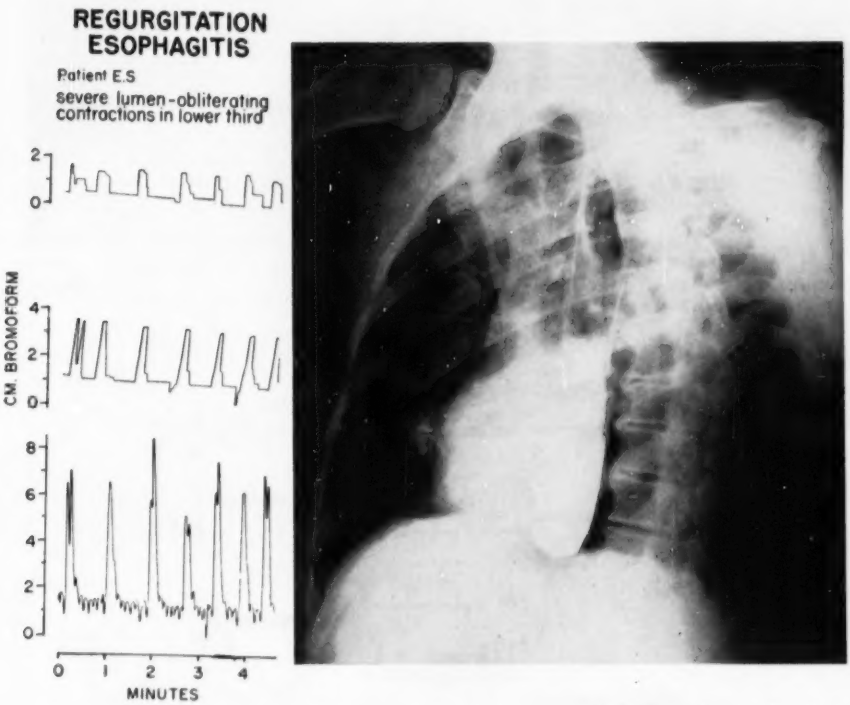

Fig. 6*A*.—Severe lumen-obliterating contractions in lower one-third of esophagus of patient with severe regurgitation esophagitis.

Fig. 6*B*.—Esophagram of same patient showing barium retention and esophageal dilatation due to functional obstruction. Esophagoscope could be easily passed into stomach.

TABLE 2.—*Summary of Preoperative and Postoperative Findings, Including Bethanecol (Urecholine) Effect, in Patients Subjected to Cardioesophageal Myotomy*

	Preoperative				Postoperative			
	Before Bethanechol		After Bethanechol		Before Bethanechol		After Bethanechol	
Patient	Frequency *	Amplitude †	Frequency	Amplitude	Frequency	Amplitude	Frequency	Amplitude
E. T.	2	1	7	1.5	8	2.5	10	3.5
E. W.	0	0	0	0	2.5	2.5	1	2
N. T.	0	0	0	0	1	2	0.5	1.5
E. B.	0	0	0	0	2.5	2	3	2

* Contractions per minute.
† In centimeters of bromoform averaged from 3 balloons.

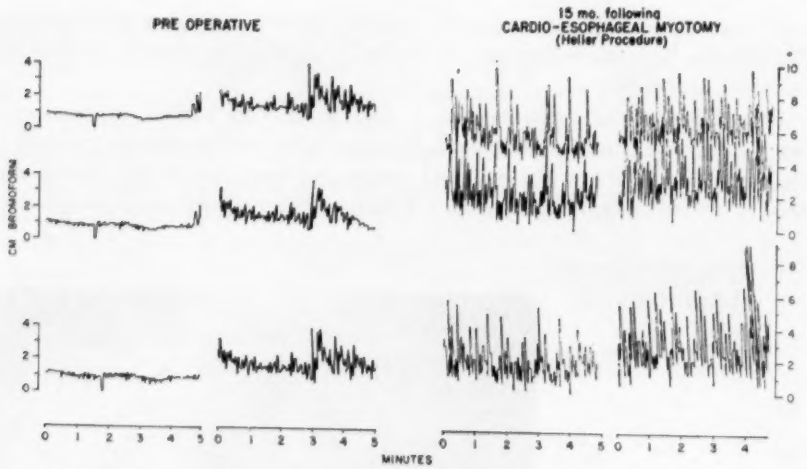

Fig. 7.—Pronounced change in frequency and amplitude of contractions which followed operation on Patient E. T. (moderately advanced cardiospasm). The tracing at the right in each pair was taken after administration of 5 mg. of bethanechol.

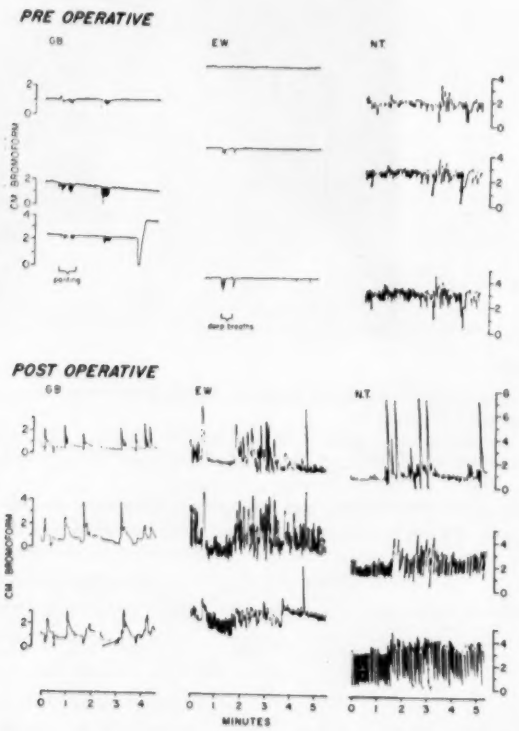

Fig. 8.—Striking postoperative alterations in frequency and amplitude of contractions in remaining three patients (cardiospasm far advanced).

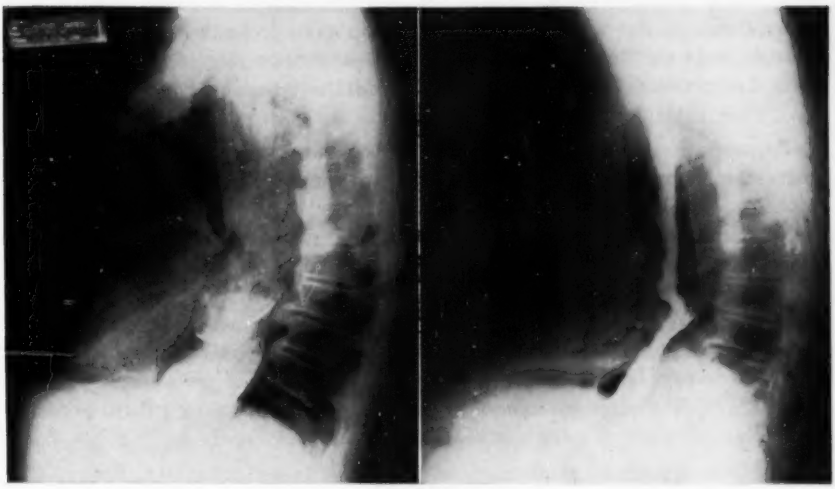

Fig. 9.—Pre- and postoperative roentgenograms showing moderate decrease in esophageal dilation which was accompanied by relief of obstructive symptoms.

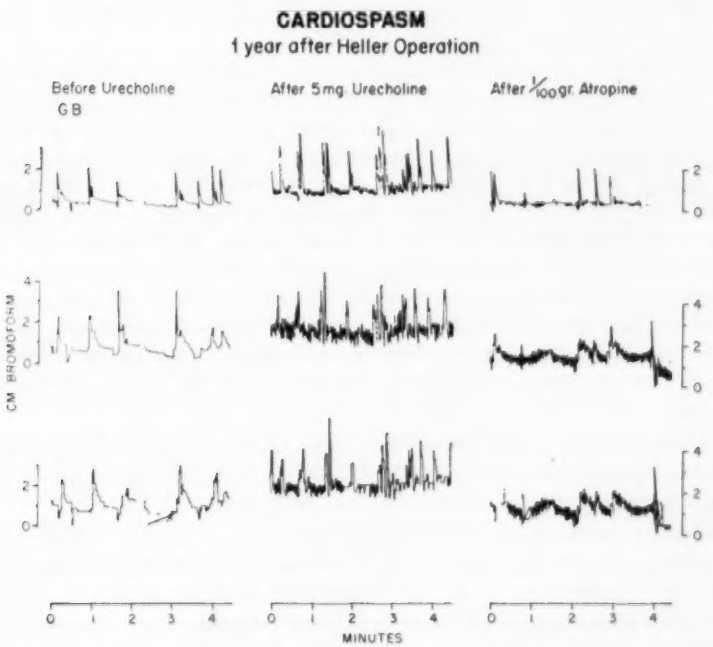

Fig. 10.—Effects postoperatively of bethanechol and atropine administration. Left tracings, before bethanecol; center tracings, after 5 mg. of bethanecol; right tracings, after 0.60 mg. (1/100 grain of atropine).

cases, 5 to 10 minute intervals free of any contractions were observed. Intrathoracic pressure changes due to respirations were much more pronounced, owing to a lack of esophageal tone. Bethanechol preoperatively produced no significant effect in four of the five patients. One patient exhibited a mild increase in frequency of contractions. (See Table 2.)

Postoperative motility studies carried out on an average of 18 months after the Heller-Zaaijer operation in four of the five patients revealed a striking change in esophageal motility. This was evidenced by a marked increase in both frequency and amplitude of contractions. However, the contractions remained of a partially disorganized character. Bethanecol produced only minor alterations in frequency of contractions beginning 15 to 20 minutes after its administration. (See Figs. 7 and 8.) A minor increase in esophageal tone was noted after administration of bethanechol in the patients studied postoperatively. Postoperative esophagrams revealed a significant reduction in size, which varied with the amount of preoperative dilation. (See Fig. 9.) The administration of atropine to one postoperative patient produced a significant decrease in amplitude of contractions. (See Fig. 10.)

COMMENT

Etiologic theories pertaining to cardiospasm have implicated avitaminosis,[7] a diaphragmatic pinchcock,[13] deficiency of relaxing nervous impulses to the cardioesophageal sphincter [11] or overstimulation of sympathetic nerve fibers to this area,† psychosomatic disorders,[30] and several others.

A disease state at least partially comparable to cardiospasm in the human has been repeatedly produced experimentally in different animals by high bilateral vagal section ‡ or vagal overstimulation.[28] Macmanus and associates [20] found no loss of esophageal myenteric plexus ganglia in dogs subjected 18 months previously to high vagal section. Sympathetic denervation in the experimental animal either with or without parasympathetic denervation has given inconsistent results.§ Difficulties arising in the application of these experimental findings to the treatment of cardiospasm in the human are demonstrated by the inconsistency of the results obtained by sympathectomy.‖ This evaluation may not be valid, owing to the difficulty in the surgical removal of all the sympathetic fibers to the cardioesophageal junction.[22] Further difficulty in applying experimental observations in the animal to the human etiologic problem lies in the differing anatomy and physiology of the animal esophagus.

Uniform pathologic findings in cardiospasm, consisting of late hypertrophy of the esophageal musculature, myenteric plexus ganglia degeneration, and late stasis esophagitis due to infection, have been repeatedly observed.¶

Anatomical studies using phase microscopy carried out on 18 normal esophagi from patients who died of nonesophageal disease in this institution have demonstrated only one-third to have had the classic anatomical distribution of smooth and striated musculature. Another one-third showed significant amounts of striated

† Reference 15 and 16.
‡ References 6, 8, 9, 12, 15, 21, and 31.
§ References 1, 9, 12, 15, 16, and 31.
‖ References 1, 15, 16, and 22.
¶ References 2, 5, 17, 26, and 27.

muscle throughout the entire length of the organ. In the remaining one-third no striated muscle was found in the middle or lower third of the esophagi.[29] This finding may explain the varying extent of esophageal dilation in patients with advanced cardiospasm. The patients with an absence of striated muscle in the lower two-thirds may show more extensive esophageal dilation.

The existence and clinical significance of a true cardioesophageal sphincter has repeatedly been emphasized.# Recent observations made by us during the performance of cardioesophageal myotomy in a series of seven patients demonstrated in each case the existence of a hypertrophied sphincter-like band of circular muscle fibers at this site.

The observations previously presented concerning the return of more normal esophageal motility patterns following cardioesophageal myotomy indicate that the esophageal paresis in the patients observed was largely of a reversible character. This fact may indicate that the paresis was secondary to an obstructive element. The partial return of esophageal motility has been observed following a U-plasty type of esophagogastrostomy by another observer.[25]

Cannon [3] noticed in experiments on the cat, whose esophagus anatomically resembles that of the human, the prevention of regurgitation of gastric contents into the esophagus by the direct action of the gastric acid upon the cardioesophageal sphincter region. This antiregurgitant reflex did not take place if the gastric contents were neutralized, but reappeared on reacidification of gastric contents. It seems reasonable to postulate that spasm of the cardioesophageal sphincter, i. e., cardiospasm, may possibly result from prolonged overstimulation of this sphincter mechanism by acid gastric chyme. Hypertrophy of the sphincter would later result. We do not yet know whether gastric hyperacidity is or needs to be a contributing factor to the development of cardiospasm. If this concept is valid, the degeneration of the myenteric plexus ganglia seen in the esophagi of patients with advanced cardiospasm can be explained as a secondary manifestation of chronic stasis esophagitis.

TREATMENT

If a brief period of conservative therapy which includes esophageal dilatation fails to give adequate, prolonged relief of obstruction, it is our opinion that early surgery should be performed. The surgical procedure of choice is one which will relieve the obstruction without destruction of the antiregurgitative function of the cardioesophageal sphincter. The preoperative stasis esophagitis should never be converted into a late regurgitation esophagitis by the performance of a sphincter-destroying or bypassing operation. The surgical procedure which to the best of our knowledge fulfills these criteria is the Zaaijer modification of the Heller cardioesophageal myotomy.

SUMMARY

The past and recent anatomical and physiological concepts which are pertinent to a study of cardiospasm are reviewed.

A method for the study of esophageal motility utilizing three simultaneously recording balloons is presented. Pre- and postoperative esophageal motility studies

References 14 and 18.

have been carried out on four patients with cardiospasm who were subjected to a cardioesophageal myotomy. The preoperative esophageal paresis has been markedly altered postoperatively toward a more normal motility pattern. This observation suggests that the esophageal paresis in patients with cardiospasm is of a reversible nature.

These and other physiological observations outlined have suggested to us a causative concept of cardiospasm.

DISCUSSION

Dr. Earle B. Kay, Cleveland: The etiology, physiology, and pathology of achalasia of the esophagus have been subject to much conjecture for many years. It is difficult to contribute to the etiology of this condition by studying the lesion after it is well established.

During the development of achalasia, various motility patterns may be demonstrated depending upon the degree of achalasia present when first studied. Initially, during the period of functional dysphagia, there may be no significant change in the motility pattern, only a slowing or temporary hold-up in the lower esophagus. Later, as a result of the functional stenosis at the site of the inferior esophageal constrictor, an increase in the secondary and tertiary contractions may be noted above the point of obstruction [slide]. Finally the esophageal musculature becomes atonic [slide].

Evidence suggests that the muscular dysfunction present is secondary to degenerative changes in Auerbach's plexus in the lower esophagus [slide]. This causes a sympathetic preponderance resulting in failure of relaxation and subsequent hypertrophy of the inferior eosophageal constrictor to the degree of producing esophageal obstruction.

Surgical treatment of achalasia should provide relief of the esophageal obstruction but not interfere with the closing mechanism of the esophagogastric junction so that regurgitant esophagitis is produced. Since the inferior esophageal constrictor begins 1 to 3 cm. above the esophagogastric junction, and extends upward for 3 to 5 centimeters [slide], it is best approached through the thorax. The Heller operation as originally performed was through the abdomen, and undoubtedly all of these hypertrophied circular fibers were not severed.

[Slide] The chronicity and state of the esophagus when first seen depend a good deal on what such motility studies will show, and perhaps the prognosis. In the development of cardiospasm the motility pattern is greatly increased, as demonstrated here. There are increased secondary and tertiary contractions.

The criticism in reference to the term "cardiospasm" is the fact that the etiology, the point of obstruction, is not at the esophagogastric junction, but 2 to 3 cm. above this junction.

[Slide] As the condition develops, more and more dilatation of the esophagus takes place.

[Slide] Finally one gets a megaesophagus, as seen here, that will fill the entire chest.

As far as the etiology is concerned, it is a matter of conjecture. However, the main evidence does point to something wrong with the Auerbach plexus.

[Slide] Probably other findings are secondary. In most instances some degeneration of the entire plexus can be found, such as seen here as fibrosis of the ganglia—[slide]—to far-advanced cases, where no ganglia can be found whatever yet nerve fibers are normal.

[Slide] I think it is important to know the anatomy of this region. This is a dissection of a normal lower esophagus and esophagogastric junction. There is a closing mechanism from the oblique and inner muscle fibers of the stomach, but this plays no part in a closing mechanism or opening during swallowing. The lower esophagus is fairly devoid normally of circular, spiral and oblique fibers. It is mainly a longitudinal layer.

At this point, 1 to 3 cm. above the junction, the lower esophageal sphincter or constricture is found, which is a development of circular muscle. At this site, longitudinal fibers from the longitudinal layer go in and connect with this constricting sphincter, and also the diaphragmatic esophageal ligament attaches there. Also these play a factor in the opening and closing of this area.

[Slide] It is important to know that in achalasia of the esophagus invariably one can find a hypertrophied circular muscle fiber similar to what one finds in pyloric stenosis. By severing this alone, one can usually relieve the condition almost invariably, and if the esophagus above is not too far dilated, not too atonic, an essentially normal esophagus may return.

It is important to realize that the muscle fibers may extend 3, 4, or even 5 cm. up in the esophagus; so that in approaching this operation one should do it through the thorax; otherwise, as originally done by Heller, it was done through the abdominal approach, and all these fibers were not obtained.

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TOTAL GASTRECTOMY WITH REPLACEMENT UTILIZING THE TRANSVERSE COLON

Preliminary Report

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TOTAL gastrectomy is being increasingly favored for use in all cases of gastric cancer. Carcinoma may spread for considerable distances within the wall of the stomach, and it may extend into the adjacent duodenum and esophagus. Recurrences following subtotal gastrectomy for carcinoma develop at the anastomotic site in about three-fourths of cases. However, total removal of the stomach has produced a disabling state in many patients. Most of such patients fail to gain weight. As a result of lack of reservoir space for ingested foods, an ordinary quantity of food cannot be taken at one time. After the usual methods of reconstruction, ingested food is deviated away from the duodenum and first portion of jejunum. Protein digestion appears to remain adequate, and those totally gastrectomized patients who have difficulty with steatorrhea and diarrhea appear to suffer from the too rapid emptying of the jejunum rather than from an incompleteness or an insufficiency of chemical digestion.

For this reason, it has been felt by many observers that the most important contributing factor in this disability of totally gastrectomized patients is the absence of a mechanical reservoir. This "crop function" of the stomach is an old one phylogenetically, but certainly it is an important one functionally. Hoffmann,[1] in 1922, first constructed a gastric reservoir utilizing the principle of the Finney pyloroplasty; the gastric reservoir was formed by uniting both arms of the jejunal loop.

Wullstein,[2] in 1904, proposed making an intestinal loop serve as a replacement for the esophagus and stomach. Roux,[3] in 1907, suggested replacing the esophagus and stomach by an intestinal loop of jejunum separated in part from its mesentery. The first recorded use of a segment of the colon, and, indeed, the transverse colon, for such a purpose has been given by Vulliet [4] in 1911. The hepatic-flexure end of the transverse colon was anastomosed to the stomach, while the splenic-flexure end was anastomosed to the esophagus in the cervical region. Kelling [5] utilized a segment of transverse colon similarly in a prethoracic esophagoplasty by anastomosing the splenic end to the stomach and extending the proximal end to the level of the

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breast. In 1923 Roith [6] used the entire proximal portion of the colon, that is, the cecum and the ascending colon and a portion of the transverse colon, as the connecting bridge between the cervical esophagus and the stomach in a prethoracic esophagoplasty.

Lee [7] recently has reported his experimental and clinical results in using the ileocolon for replacing the stomach following total gastrectomy. Hunnicutt [8] has reported several cases in which a similar procedure has been carried out. State [9] utilized a segment of transverse colon to replace the excised stomach and esophagus.

All operative procedures on the colon depend for their ultimate success upon the careful consideration and preservation of adequate blood supply. The anastomoses between the right, middle, and left colic arteries, and those between the left colic and sigmoid arteries, are so free by way of the communicating loops situated near the mesenteric border of the bowel, that it is necessary to take care only to spare those loops in ligating the vessels of the mesosigmoid and the mesocolon (Archibald,[10] Drummond [11]). The transverse colon is vascularized by the left branch of the right middle colic artery which continues without decrease in caliber in a voluminous marginal arcade of 35 cm. length in the midportion up to its inosculation with the artery of the left angle, which has a length of about 15 cm. The mobilization of the transverse colon and its mesocolon in preserving only the marginal arcade and a band of peritoneum always allows the left colic angle to be elevated on the average of 30 cm. from the origin of the middle colic artery (Toupet [12]). The left colon, including the transverse colon, can be mobilized and preserve a sufficient vascularization with the right colic artery as the only pedicle.

The colon and its nutrient blood vessels may be compared to a rubber-tired wheel with irregularly placed spokes. The spokes represent the named colic arteries, while the rim represents the marginal artery from which the terminal branches arise. However, the vascular pattern of each colon is original, and each case must be analyzed and treated individually. The vessels supplying the portion of the bowel involved in any procedure must be identified in all surgical procedures.

The use of the ileum and right colon is based upon the fact that the right colon is sufficiently large to act as an adequate reservoir. It has the advantage that it is not involved even in extensive, locally invasive gastric carcinomas, since it is outside the area of regional lymphatic drainage of the stomach. It has been alleged that the ileocecal valve can function as effectively as the cardia to prevent the regurgitation of bile and pancreatic juice into the lower esophagus. In a certain percentage of cases this valvular mechanism is incompetent with the structure in normal position. If it were competent in its normal position, it is questionable whether it would remain so under the conditions of the transplant.

In addition to the properties of distensibility, mobility, and good vascularization, the transverse colon has the additional property that longer segments, including the ascending and descending colon, can be mobilized and used when the carcinoma of the stomach extends into the esophagus for considerable distance. Orsoni and Lemaire [13] have shown that it is easy to obtain long segments of transverse and descending colon for different types of esophagoplasty.

In addition to the factors favoring the use of the transverse colon as a replacement for the gastric pouch, certain unfavorable factors must be considered. The first and outstanding consideration is whether or not the neostomach possesses enough intrinsic resistance to the action of regurgitated bile, pancreatic juice, and

intestinal juice to prevent the initiation of a chemical colitis. A second problem is whether or not the intercalation of a segment of transverse colon will prevent the regurgitation of the alkaline juices of the upper reaches of the duodenum and small intestine from initiating an alkaline esophagitis. Lortat-Jacob [14] has emphasized the significance of alkaline regurgitation in producing esophagitis in explaining some of the poor results following esophagojejunostomy, including stricture formation.

REPORT OF CASES

CASE 1.—K. K., a 62-year-old housewife, complained that for the past seven years she had had a postprandial "pinching" pain in the epigastrium. During the preceding six months the pain had increased in intensity. Five years before admission she weighed 160 lb. (73 kg.); one month prior to admission she weighed 146 lb. (66 kg.) and upon admission was found to weigh 135 lb. (61 kg.).

Examination was essentially negative except for multiple large varicosities on both legs. There was moderate pitting edema over the distal two-thirds of the legs associated with stasis dermatitis and pigmentation.

Urinalysis was negative. There was a mild hypochromic anemia.

Barium enema showed no abnormality in the large bowel or terminal ileum. An upper gastrointestinal examination showed a polypoid tumor mass involving the anterior and posterior surfaces of the greater curvature of the stomach.

Gastroscopy demonstrated an infiltrating carcinoma involving the greater curvature and the anterior and posterior walls. The lesion extended almost to the cardia.

Transabdominal total gastrectomy was performed; the entire stomach, greater omentum, gastrohepatic omentum, spleen, and distal half of the pancreas were removed. Continuity was reestablished by an esophagojejunostomy and side-to-side jejunojejunostomy (Braun anastomosis).

Pathological examination of the specimen showed a diffuse linitis plastica type of adenocarcinoma with lymph node metastases to the gastrohepatic omentum and the nodes of the splenic hilus.

Postoperatively her general condition was good, and she quickly advanced to a soft diet. Diarrhea developed on the 5th postoperative day but had disappeared by the 14th postoperative day. She was discharged three weeks postoperatively on a diet consisting of six soft feedings a day.

One month later her weight had fallen off to 112 lb. (51 kg.). Her appetite was poor, and she was unable to take much food at one meal; if she attempted to do so, she would vomit. She had no pain, and her bowels moved every other day without difficulty. Three months postoperatively she complained of anorexia with intermittent substernal burning with occasional regurgitation of food. A roentgenogram showed an esophageal ulcer. Esophagoscopic examination demonstrated the presence of esophagitis with ulceration; this was proved by histological examination of a tissue biopsy. She was given alumina medications with some alleviation so that she could eat Jell-O and soft foods, but other ailments caused aggravation of the substernal burning. At times this heartburn became so severe that it radiated into the arms on the lateral aspect above the elbows.

She was admitted to the hospital 18 months later for bilateral hydrothorax; paracentesis gave marked relief. She died two months later of metastatic carcinomatosis.

Comment.—This case illustrates several features which we have found to follow the ordinary type of total gastrectomy followed by esophagojejunostomy. In spite of the fact that the patient's course was progressively downhill because of a metastatic malignant growth, it is to be noted that she lost weight disproportionately. Her appetite was poor, and she was unable to take much food at any meal. Esophagitis occurring after this procedure is not unknown. In this case it had become of sufficient severity to produce actual ulceration, as demonstated by the esophagoscope.

CASE 2.—G. L., a 53-year-old woman, complained of attacks of epigastric pain and occasional vomiting for the preceding seven years. In July, 1950, she had been treated for an ulcer of the lesser curvature which disappeared after one month of intensive medical therapy. She had lost weight for the preceding six months. After an attack of influenza in January, 1953, she had had a constant, dull, intractable epigastric pain radiating around the left costal margin to the back, associated with vomiting, hematemesis, and melena. Weight loss of 20 lb. (9 kg.) had occurred since September, 1952, her weight declining from 102 to 82 lb. (46 to 37 kg.) with severe weakness for the three weeks prior to admission.

Examination demonstrated a fairly well-developed, moderately emaciated woman appearing chronically ill. Her skin was loose but had fair turgor. The abdomen was scaphoid and soft with many striae but no scars. Moderate epigastric tenderness was present, but no rigidity.

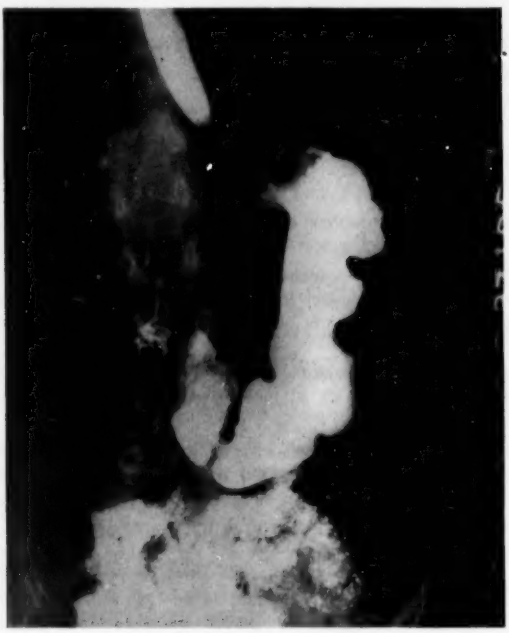

Fig. 1 (Patient G. L.).—Three benign ulcers were found in this stomach following resection. One was juxtacardial. A second ulcer was found on the lesser curvature 4 cm. below the cardial ulcer; a third ulcer was found on the greater curvature.

Urinalysis on admission was essentially negative. Examination of the blood demonstrated a hemoglobin value of 12 gm. per 100 cc. Gastric analysis showed the fasting specimen to have no free acid, and the first and second postfeeding specimens showed no free acid. The gastric content was positive for blood by the guaiac test. No malignant cells were found in the gastric juice in three successive specimens.

Roentgenographically the stomach presented an ulcer defect which measured 2 cm. in diameter on the lesser curvature. Another ulcer was found 4 cm. below this one (Fig. 1). Repeat roentgenological examinations carried out three weeks later showed that the lesser curvature ulcer previously noted had become considerably smaller, but a crater was still present. Gastroscopy demonstrated one ulcer with ill-defined margins high on the lesser curvature.

On May 1, 1953, a posterolateral incision was made, resecting the eighth rib; it was extended anteriorly through the costal margin and transected the left rectus abdominis transversely so

that the approach was a combined transthoracic, transdiaphragmatic, transabdominal one. The left lower lobe was densely adherent to the left diaphragm and was separated from it. An incision was made in the diaphragm from the edge through the tendinous portion to the hiatus.

A large mass was found involving the cardia of the stomach and associated with several large lymph nodes about the left gastric vessel. Total gastrectomy was performed, removing the omentum from the transverse colon and removing the gastrohepatic omentum and the spleen. The duodenum was transected just below the pylorus. The stomach was rotated superiorly after ligation of its four vascular pedicles.

The cecum and terminal ileum were next exposed and the vascular arcades visualized. Appendectomy was performed in the usual manner. The ileum was transected approximately 12 cm. from the ileocecal valve, and the ascending colon was transected at the junction of its proximal two-thirds and distal one-third. The distal end of the ascending colon was closed in two layers. An end-to-side ileotransverse colostomy was performed, and the cut edges of the mesentery of the ileum and ascending mesocolon were approximated. The cecal pouch with the attached ileum thus had as its vascular supply the ileocolic artery, and this pouch, together with the vascular supply, was brought through a rent in the transverse mesocolon placed to the left of the middle colic artery so that the pouch was rotated into the supramesocolic compartment posterior to the colon. The rent in the transverse mesocolon was closed. An end-to-end anastomosis was made between the ileum and esophagus in two layers. The distal end of the colon pouch was anastomosed to the duodenum end-to-end in two layers. The diaphragm was reconstructed, utilizing interrupted sutures.

On the lesser curvature of the resected stomach 4 cm. from the esophageal stump was the proximal edge of a triangular ulcer, the crater of which measured 1 by 1.5 by 1.5 cm. The edges were slightly raised, and the base was yellowish-gray. The surrounding stomach wall was thickened, edematous, and fibrosed. Another ulcer was found in the midportion of the greater curvature; a third ulcer was present in the midportion of the lesser curvature. Both of these ulcers appeared to be benign grossly and were of the callous variety. Histologically, all three ulcers were found to be benign. In the omenta attached to the lesser and greater curvatures, many nodes were enlarged and appeared grossly to be hyperplastic; this was confirmed histologically.

Her postoperative course was very satisfactory. During the first week she was advanced uneventfully to a six-feeding soft diet. On the 13th postoperative day she complained of postprandial cramps, which disappeared after two weeks of treatment with belladonna. On Oct. 1, 1953, her weight was 81 lb. (37 kg.); the cramps had become less severe, and she was not taking any belladonna.

On Nov. 4, 1953, her hemoglobin was 12.5 gm. per 100 cc.; the total red cell count was 3,310,000. Esophagoscopy showed a normal esophagus. Roentgenographic examination of the gastrointestinal tract was carried out at this time and showed a normal esophagus. The esophagoileal anastomosis and the colonic pouch and the coloduodenal anastomosis were visualized. There was excellent functioning of the artificial gastric pouch (Fig. 2). The barium passed slowly through the haustra of this gastric pouch and then progressed normally through the duodenum and into the small bowel. No abnormality was noted in the examination of the small bowel, and there was normal progression of barium into the colon.

Her progress since that time has been satisfactory. She was seen in January, 1953, following dietary indiscretions incident to a New Year's eve celebration. Her weight had increased to 90 lb. (41 kg.) since operation.

Comment.—At the time of operation, as so frequently is the case with these lesions, it was impossible to determine whether or not the juxtacardial lesion was malignant. The occurrence of gastric ulcers over a period of time had produced considerable disability in this woman. Postoperatively, the occurrence of cramps following the ingestion of food was a marked complaint; fortunately, it disappeared promptly upon treatment with belladonna.

Certain features in the technical performance of this procedure suggested to us that in those cases in which the carcinoma extended to a higher level of the esophagus

it might be more advantageous to use the transverse and descending colon. In this particular case the vascular pedicle, which consisted of the right ileocolic vessels, was stretched about to its maximum capacity during this procedure, even though the ileum and colon were placed through the transverse mesocolon and posterior to the transverse colon. The frequent recurrence of carcinoma at the proximal suture line in these cases makes it desirable to transect the esophagus at a higher level than is frequently done, and for this purpose, one could more easily use a long segment of transverse and descending colon.

CASE 3.—R. C. B., a 73-year-old white man, had developed epigastric pain of mild severity eight months prior to admission. On the afternoon he was admitted to the hospital he became nauseated and vomited a cupful of bright-red blood. He had lost 15 lb. (7 kg.) during the

Fig. 2 (Patient G. L.).—Appearance following barium meal after total gastrectomy and ileocolon transplant.

preceding six months. There was no history suggestive of ulcer. He had shortness of breath on exertion and a dry cough for years. Pedal edema had been progressive for the past three years.

Examination showed a well-developed white man who walked with a marked limp; he was quite short of breath on exertion and had an irritating dry cough. The lung fields presented occasional scattered inspiratory dry rales, best heard at the bases. The abdomen showed three well-healed scars with obliteration of the umbilicus. A mass which was not attached to the abdominal wall and which moved inferiorly with inspiration was felt in the left upper quadrant near the midline. It was hard, slightly tender, and measured about 3 by 4 cm. No liver or spleen could be felt. The rectal examination was negative. The right femoral head was elevated 6 cm. over the left.

Urinalysis was negative. Examination of the blood showed a hemoglobin value of 7.5 gm. per 100 cc. The total leucocyte count was 7,400, with 65% polymorphonuclear leucocytes. Total

protein was 5.05 gm. per 100 cc., with albumin of 2.82 gm. and globulin of 2.23 gm. Gastric analysis showed no free acid in either specimen; occult blood was present in the gastric content. An electrocardiogram was read as showing a normal sinus rhythm with occasional premature ventricular contractions. Left axis deviation was present, with low voltage in the standard and unipolar leads.

Barium enema showed no evidence of intrinsic colon pathology. A gastrointestinal series showed a normal esophagus with a small hiatus hernia and an ulcer crater in a ragged-appearing fundus (Fig. 3).

Roentgenographic examination of the chest showed the changes of advanced pulmonary silicosis and emphysema. The heart was at the upper limits of normal in size and presented no abnormal configuration. There was some blunting of both costophrenic angles. The pulmonary vessels were heavy.

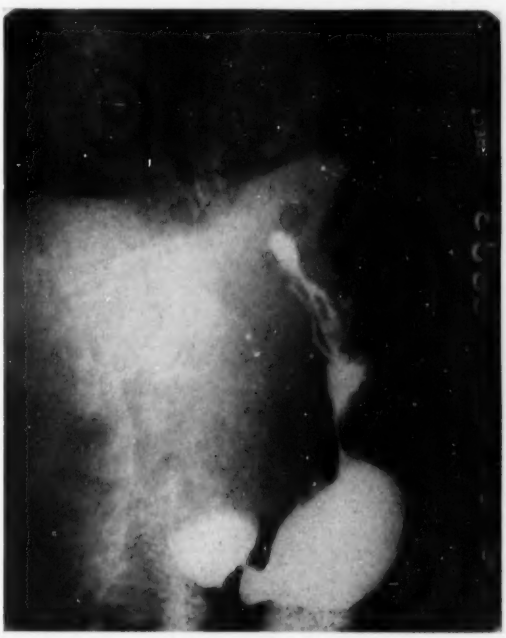

Fig. 3 (Patient R. C. B.).—Extensive carcinoma involving the cardia and fundus of the stomach.

Gastroscopy was performed with the use of local anesthesia. A slight obstructive sensation was encountered in the upper portion of the stomach. A white, hard, irregular mass with poorly defined edges with accompanying adjacent polypoid formation was seen in the fundus of the stomach. There were numerous areas of hemorrhage throughout the mass. The impression was carcinoma of the stomach.

Esophagoscopy visualized the lower end of the thoracic esophagus and the esophagogastric junction; the junction appeared normal, although the scope could not be readily introduced into the stomach. There were no mucosal lesions in the lower end of the esophagus, and its walls seemed to be normally flexible without fixation.

Operation was carried out on July 15, 1953. The following procedures were performed: (1) transthoracic, transdiaphragmatic, transabdominal, total gastrectomy, and (2) splenectomy with (3) esophagotransverse colostomy, and (4) transverse coloduodenostomy; (5) colocolostomy (end-to-end); (6) lung biopsy.

The body, fundus, and cardia of the stomach were the site of a very extensive carcinoma which had extended locally to invade the gastrohepatic omentum, the greater omentum, the transverse mesocolon, and the transverse colon itself.

Because the tumor encroached upon the cardia and because bleeding had been a presenting symptom, a palliative gastrectomy was elected. The gastric mass, including the entire stomach with greater omentum, gastrohepatic omentum, and spleen, was thus freed up, and the distal portion of the esophagus was mobilized up to the inferior pulmonary vein.

To replace the excised stomach, a 20 cm. long pouch was constructed of transverse and descending colon. The left colic artery was ligated in the mesentery close to its origin and the circulation of the bowel depended on the middle colic and the marginal artery of Drummond (Archibald [10]); this segment of excluded colon was then available for the gastric pouch.

His postoperative recovery was somewhat slow. He took his postgastrectomy diet well and was ambulating satisfactorily. On the 11th postoperative day he first complained of epigastric

Fig. 4 (Patient R. C. B.).—After total gastrectomy, continuity was reestablished by antiperistaltic transplantation of a segment of transverse colon 20 cm. long. End-to-end anastomoses were used.

cramps and nausea and anorexia. At this time he was given belladonna, with relief. He continued to have epigastric cramps and nausea, and on Aug. 4, the 20th postoperative day, he began to have bilious regurgitation. He continued to take a soft diet and only regurgitated small amounts of undigested food during the daytime; at night he would regurgitate small amounts of bile.

He was given bethanechol chloride (Urecholine), 20 mg. t. i. d., by mouth, and psyllium hydrophilic mucilloid with dextrose (Metamucil) every two hours. These measures were followed by marked alleviation of the regurgitation.

His chronic cough continued but had become productive, and on Aug. 6, examination of the lungs showed signs of a left lower lobe pneumonitis confirmed by roentgenogram. Cultures of the sputum showed the presence of Staphylococcus aureus. By Aug. 14, he had become afebrile, but the presistent cough continued. At this time a roentgenological examination showed that

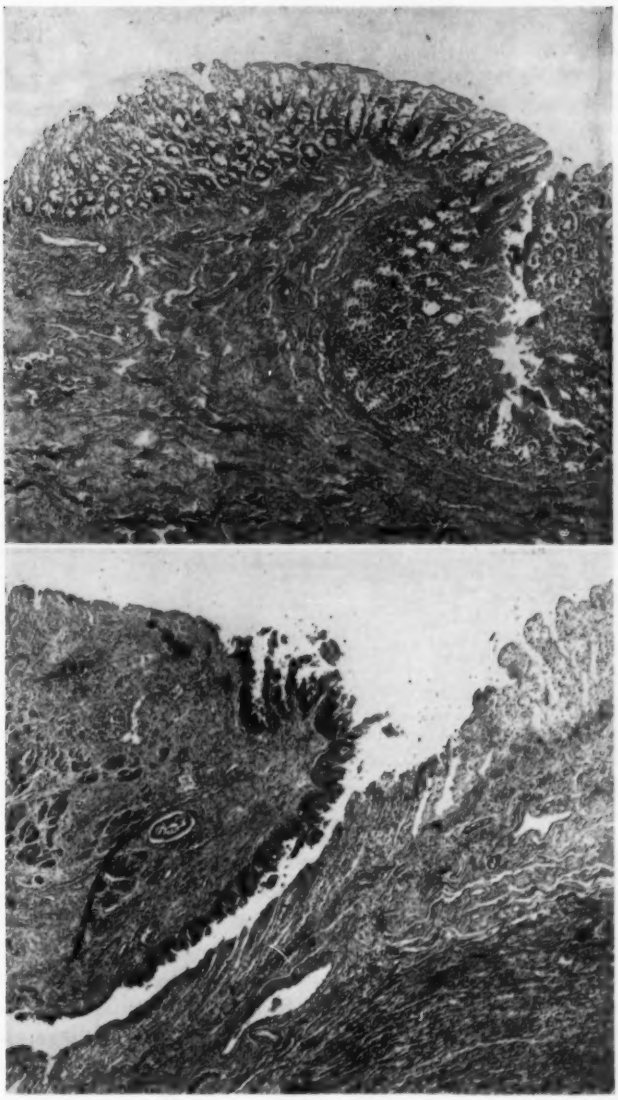

Fig. 5 (Patient R. C. B.).—Section of colon pouch. There is no evidence of an inflammatory reaction.

Fig. 6 (Patient R. C. B.).—Section of esophagocolic junction; no evidence of inflammatory changes.

the esophagus was normal. The stomach was seen to have been replaced by a segment of colon through which the barium was seen to pass readily into the duodenum without hesitation (Fig. 4). Films taken one and two hours later showed the progress of the barium in the small bowel, and some barium was seen in the terminal ileum on the two-hour film.

By Aug. 20, his general condition had improved to the extent that he was taking four meals daily with comfort and was tentatively scheduled for discharge on Aug. 21. Shortly before the time he was to leave the hospital, he suddenly collapsed and died while walking to the bathroom.

Autopsy examination showed massive pulmonary emboli, bronchopneumonia, and bronchiectasis, with areas of metastatic carcinoma. There was extensive generalized arteriosclerosis. The esophagus, stomach, and duodenum were removed en bloc. The anastomotic sites were well healed; there was no evidence of inflammatory changes in the segment of transplanted colon or the esophagus. The gross impressions were substantiated by histological examination (Figures 5, 6, and 7).

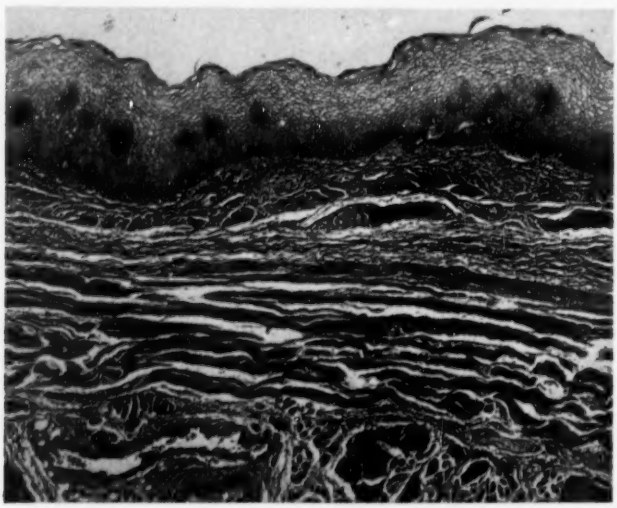

Fig. 7 (Patient R. C. B.).—Section of esophagus 1 cm. above esophagocolic junction; no evidence of inflammatory changes.

Comment.—In spite of the fact that a complete vagotomy had certainly been performed in transecting the esophagus, diarrhea was not a feature of this patient's postoperative state. He was taking a postgastrectomy diet without difficulty until the 11th postoperative day, when he first developed epigastric cramps, nausea, and anorexia. Belladonna gave relief. He continued to have intermittent postprandial cramps, and on the 20th postoperative day he began having regurgitation of small amounts of bile, especially at night. Marked alleviation of the regurgitation was produced by bethanechol chloride and psyllium hydrophilic mucilloid with dextrose.

Case 4.—K. E. P., a 70-year-old white male laborer, was admitted with the complaint of stomach trouble of four weeks' duration. He apparently had been well until the present illness, when he began to have a severe, rather sharp intermittent pain in the periumbilical region radiating to the epigastrium and into the center of the chest and occasionally to both flanks. He had lost 20 lb. during the past year and recently had been feeling very tired and weak. His appetite began to decrease when he had stopped working in 1947, and he had been somewhat depressed since that time.

Examination showed a small, thin, elderly, deaf, white man who had lost considerable weight. There was some voluntary guarding in the epigastrium and tenderness to palpation in that area. Bilateral small indirect inguinal hernias were easily reducible.

Urinalysis was negative. Examination of the blood showed a hemoglobin of 13 gm. per 100 cc. Total protein was 6.45 gm. per 100 cc. Free acid was present in the stomach content following a test meal. An electrocardiogram showed a sinus tachycardia with prominent P_2 and P_3. Occasional premature ventricular contractions were present.

Barium enema showed a normal colon. The chest roentgenogram showed considerable emphysema bilaterally. Gastrointestinal series showed a normal esophagus. On the lesser curvature approximately 3 cm. from the esophageal entrance was a large ulcer crater which extended out from the stomach wall approximately 1.5 cm.

After a three-week trial of medical therapy during which time the ulcer failed to show any change roentgenologically, surgical therapy was advised.

Fig. 8 (Patient K. E. P.).—After total gastrectomy continuity was reestablished by antiperistaltic transplantation of an 18 cm. segment of transverse colon.

Operation was carried out on May 22, 1953. A thoracoabdominal incision was made through the left eighth rib bed. The stomach was examined and presented a large ulcer on the lesser curvature; the indurated border of the ulcer extended well up on the lesser curvature almost to the cardia. Total gastrectomy and splenectomy were carried out. Continuity was reestablished by intercalating an 18 cm. segment of transverse colon, esophagocolostomy and coloduodenostomy being made in end-to-end fashion.

Pathological examination of the resected specimen showed a juxtacardial ulcer on the lesser curvature of the stomach; it measured 3 cm. in diameter. The border was very hard and piled up. Serial microscopic sections demonstrated it to be a benign peptic ulcer.

The patient was ambulatory on the first postoperative day. On the fourth postoperative day he developed diarrhea and became markedly dehydrated. Intermittent diarrhea continued, and on June 13 he first developed postprandial regurgitation. Roentgenographic examination of the upper gastrointestinal tract on July 2 showed that the barium meal passed easily through

the esophagus to the neostomach, which apparently lay ½ in. (1.3 cm.) below the diaphragm. The pouch appeared to be about 10 in. (25 cm.) long (Fig. 8). The stoma into the duodenum functioned well, without any delay of the barium. Esophagoscopy showed the esophagus to be entirely normal. The junction between the esophageal and colic mucosa was seen just above the diaphragm. There were no mucosal lesions or stricture.

About July 5 he began to be very depressed, and feeding became a difficult problem. His emotional state continued to be very depressed, and he frequently stated that he wanted to die. On July 7 he was given tube feedings by slow drip. Because of his emotional situation, he was transferred to the psychiatric service. The diarrhea disappeared, and he was able to be about the ward. He was able to eat three meals daily with between-meal feedings. The regurgitation gradually disappeared. His weight remained stable; he gained 6 lb. (2.7 kg.) after operation. Although he was well oriented and seemed to be in about the same general mental state that he had presented upon admission, the prognosis was guarded because of his age and generalized arteriosclerosis. He was discharged after four weeks of psychiatric treatment, and he died five months later of a cerebrovascular accident. An autopsy was not obtained.

Comment.—Although this man had, in retrospect, definite symptoms of a senile depression preoperatively, the true state of affairs was recognized only in the postoperative state. His diarrhea is to be attributed to the complete vagotomy. His refusal to eat apparently was on an emotional basis. There was no evidence of esophagitis. His rehabilitation was felt to have been reasonably satisfactory in the hospital, but his prognosis was guarded because of the underlying organic psychogenic condition. He had a transient period of postprandial regurgitation, which had subsided by the fifth postoperative week.

CASE 5.—M. H., a 59-year-old man complained of nausea, vomiting, and burning epigastric pain after meals; all these symptoms had been present for the preceding eight weeks. He had had a known duodenal ulcer with complications for the preceding 20 years, for which he had undergone nine operations.

He had first been seen in our outpatient department, with complaints of epigastric pain, nausea, and vomiting occurring in attacks for the past year. A cholecystogram showed the presence of gallstones, and cholecystectomy was carried out in November, 1952. He failed to obtain relief, and a gastrointestinal series on Jan. 13, 1953, showed a constant large pocket at the region of the stoma, identified as a marginal ulcer. His symptoms continued intermittently and in February he had his first recurrence of black tarry stools. Transthoracic vagotomy for marginal ulcer was done in March.

Two and one-half months following the vagotomy he began having recurrent abdominal pain. His weight had declined from 195 lb. (88.5 kg.) two years previously to 135 lb. (61 kg.) on admission.

Examination showed an emaciated, well-developed white man. Many old operative scars were present. Right upper quadrant tenderness was present.

Urinalysis was negative. Blood examinations showed the hemoglobin content to be 12.5 gm. per 100 cc. The total proteins were 6.6 gm. per 100 cc. Gastric analysis on three different occasions showed complete absence of free hydrochloric acid.

A gastrointestinal series was carried out on June 29 (Fig. 9). The defect which had been previously seen on the greater curvature side of the gastric pouch was noted and was interpreted as a marginal ulcer. In addition, the gastric pouch appeared to be distended and appeared to contain at least 400 cc. of material 12 hours later. This was interpreted as an obstructing marginal ulcer with gastric retention. Barium enema on July 20 showed no abnormalities.

Operation was performed on July 30. A left thoracoabdominal incision was made. The entire upper abdomen was the site of many thick dense adhesions. The dissection was made very difficult because the stomach was markedly distended with food and fluid. The jejunum, at the site of anastomosis, was markedly obstructed and deformed by a huge ulcer which extended into the jejunal mesentery for considerable distance. This was carefully separated from the mesocolon on all sides, and, finally, it was separated from the stomach.

When the stomach was adequately decompressed, it was noted that an adequate resection had previously been performed. The jejunum was so badly deformed that the affected segment had to be resected and the jejunum was reconstructed.

The remaining gastric pouch was resected completely. Continuity was reestablished by intercalating a 24 cm. segment of transverse colon between the esophagus and the jejunum. The distal end of the colon segment was anastomosed to the esophagus. The proximal end was joined to the jejunum at a point 12 cm. distal to the site of the jejunojejunostomy. Coloduodenostomy was impossible because of the previous procedures.

Histological examination of the resected jejunum confirmed the gross diagnosis of peptic jejunal ulcer.

The immediate postoperative course was uneventful. On the seventh postoperative day he was taking the routine postgastrectomy diet well. Diarrhea up to seven stools daily appeared on

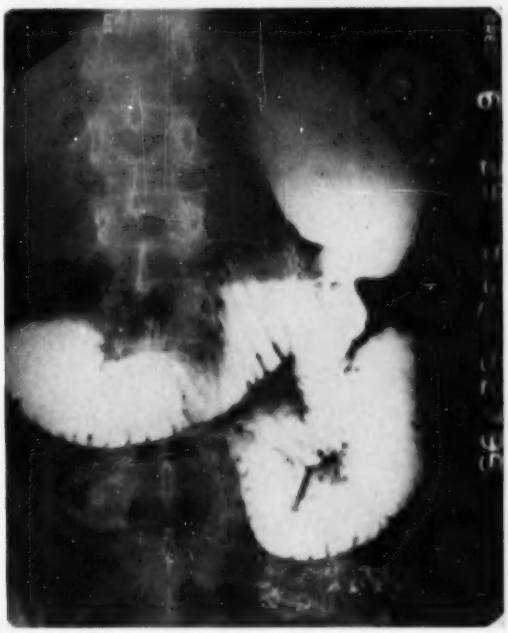

Fig. 9 (Patient M. H.)—After subtotal gastric resection a marginal ulcer developed which produced obstruction of the stomach and jejunum.

the 10th postoperative day. On the 12th postoperative day he complained of right upper quadrant abdominal pain immediately during and after meals, with some regurgitation of previously eaten food. He was given psyllium hydrophilic mucilloid with dextrose, 1 fluidounce (29.5 cc.) every two hours, and camphorated tincture of opium, 4 cc. every four hours. He began to take his diet well again following this therapy. On the 15th postoperative day, roentgenological examination showed the anastomosis of the esophagus to a loop of colon and the anastomosis of the latter to a loop of jejunum to be free with no evidence of obstruction (Fig. 10). The small bowel pattern distal to the esophagojejunocolostomy appeared normal. On Aug. 19 (the 20th postoperative day) he had no complaints and felt well. He was discharged on Aug. 28, being given tablets of psyllium hydrophilic mucilloid with dextrose.

He was seen in the surgery outpatient department on Sept. 3, 1953, at which time he weighed 121 lb. (55 kg.). He had only occasional postprandial distress. His bowels were active, sometimes up to five times daily, but there has been no vomiting or abdominal pain.

Fluoroscopic and radiographic examination of the upper gastrointestinal tract on Jan. 8, 1954, following the oral administration of barium, showed some delay in emptying at the site of the anastomosis between esophagus and colon. Emptying of the colon pouch was quite slow, and there seemed to be considerable reflux into the distal esophagus. After 45 minutes it was noted that the barium had progressed only a short distance into the small bowel. Esophagoscopy showed a normal mucosa.

Gastroscopy showed the mucosa of the colon pouch to be entirely normal.

Comment.—The multiple procedures which this man had undergone over the years for the effects of a severe ulcer diathesis represent a situation which challenges surgery at the present time. In retrospect, the transthoracic vagotomy was

Fig. 10 (Patient M. H.).—After total removal of the remaining gastric pouch a 24 cm. segment of transverse colon was transplanted and continuity was reestablished by esophagocolojejunostomy.

poorly advised in view of the organic small bowel obstruction which undoubtedly existed at that time. At any rate, it was felt that this patient did not tolerate even the small remnant of gastric mucosa which remained.

The diarrhea in his case almost certainly can be attributed to transection of vagal fibers during the excision of the esophagus. This might be considered an anomalous situation in view of the fact that the patient had had a previous transthoracic vagotomy; however, the same phenomena has been noted previously by Dr. George M. Curtis * and communicated to us. Dr. Curtis' idea, supported on rather convincing anatomical evidence, was that certain long vagal fibers could travel intramurally

* Curtis, G. M.: Personal communication to the authors.

within the esophagus rather than be collected in anatomically definable cords on its external surface. In this case the diarrhea gradually subsided over a period of time, as do most vagotomy diarrheas; however, the patient required camphorated tincture of opium intermittently for several months.

An extremely interesting feature of his postoperative convalescence was the regurgitation of small amounts of bile, especially at night. This symptom did not appear until the 12th postoperative day. In spite of the fact that his epigastric distress following the ingestion of food and the diarrhea have largely disappeared at the present time, occurring now only in intermittent attacks, he continues to have occasional regurgitation of small amounts of bile during the night and small quantities of undigested food during the daytime. The esophageal reflux seen during his last gastrointestinal radiological examination is interesting in this regard.

COMMENT

We are not advocating here the use of total gastrectomy for benign gastric lesions or for malignant gastric lesions which can be adequately resected by subtotal gastrectomy. However, it has been our experience that proximal subtotal gastrectomy followed by esophagogastrostomy leaves much to be desired in the management of juxtacardial and cardial lesions because of the occurrence of peptic esophagitis. The problem of the pathologic nature of any gastric ulcer is still existent, and a definitive method of preoperative diagnosis is eagerly awaited.

However, in those cases in which it is believed that total gastrectomy is indicated, the transverse colon offers certain advantages as a replacement for the excised stomach and esophagus, especially in cases of carcinomas of the fundus and cardia. It has excellent vascularization, and a sufficient length of intestine is obtainable so that it may be extended up into the neck if this should be necessary. The incision of choice for total gastrectomy whether replacement is by the ileocolon or by a segment of the transverse colon is a left thoracoabdominal one with a transpleural, transdiaphragmatic, transabdominal approach.

In the cases which we have reported, diarrhea has occurred in four of the five total gastrectomies, and we attribute it to the associated complete vagotomy.

Postprandial cramping, especially after the ingestion of large quantities of liquids, has been a constant feature of our cases, regardless of whether the right ileocolon or the transverse colon segment has been used for replacement. The symptom has begun rather consistently between the 10th and 13th postoperative days. It has responded to the administration of antispasmodics, which have usually been able to be discontinued within several weeks. However, one of our patients (Case 5) has continued to have intermittent attacks lasting several days; during these attacks he obtains relief with antispasmodics.

The occasional regurgitation of undigested food during the daytime and of small quantities of bile at night has been a symptom of great interest to us. It has not occurred in our one case in which the right colon and ileum was used. It has produced the least symptomatic distress of all the sequelae. Postmortem examination in one case and esophagoscopic examination in the others have given no evidence of esophagitis. This is particularly important in relation to the esophageal reflux observed radiologically in Case 5.

Thus, while postprandial cramping appears to be a result of the colon responding to abnormal stimuli to which it must become accustomed, regurgitation is due to lack of a proximal gastric sphincter and perhaps to the antiperistaltic position of the segment of the transverse colon.

Von Hacker [15] stated that the use of an excluded segment of colon in the antiperistaltic direction for a prethoracic esophagoplasty had no kind of demonstrable ill effect. He said that the contractions and especially the peristalsis remaining in this portion of bowel had never led to the regurgitation of food. Actually, however, regurgitation of food did occur in several of his cases, but he attributed this to the fact that he had anastomosed one end of the colon into the stomach by means of a side-to-side anastomosis so that a closed blind pouch remained at the colon end. Marwedel † reported several cases in which stomach content was repeatedly regurgitated through a prethoracic neoesophagus, the lower third of which was formed by a segment of transverse colon so that the anastomosis of the colon with the skin tube superiorly failed to heal. Again this experience was attributed to the method of implantation of the colon into the anterior stomach wall. Similar situations have arisen following esophagojejunostomy according to the Roux procedure. Heyrovsky ‡ reported a case which was operated upon according to the combined Roux-Herzen-Lexer procedure in which food regurgitated again and again through the superior orifice of the transplanted intestinal sling although it was arranged in a peristaltic direction.

Although in our particular cases the symptom has not been disabling or even of much moment to the patient, it is conceivable that should it persist and become more intense, it would be a source of considerable difficulty because of the production of an alkaline esophagitis. Only prolonged observation of a larger number of cases can give evidence regarding this point.

SUMMARY

Five cases are presented in which total gastrectomy was carried out and restoration of continuity was accomplished by esophagojejunostomy, by the transplantation of the ileocolon, and by the transplantation of a segment of the transverse colon.

Salient features of these cases are compared and contrasted.

Two surviving cases in which the resected lesion was benign are available for long-term evaluation.

Segments of the transverse and left colon are admirably adapted anatomically to be used as replacements for the totally excised stomach and esophagus. They restore the "crop" function of the stomach.

All types of colon segment implants are associated with certain transient postoperative disturbances.

The only potentially serious postoperative disturbance following the use of a transverse colon implant is mild regurgitation and esophageal reflux.

The incision of choice for total gastrectomy, whether replacement is by the ileocolon or by a segment of the transverse colon, is a left thoracoabdominal one with a transpleural, transdiaphragmatic, transabdominal approach.

† Marwedel, cited by von Hacker.[15]

‡ Heyrovsky, cited by von Hacker.[15]

DISCUSSION

DR. H. CALVIN FISHER, Denver: Dr. Watkins is to be commended on his successful results with the use of this substitution operation following total gastrectomy.

I would like to ask him one question: Have there been any cultures of the fluid from the substitution pouch, and would this be of any value?

DR. JAMES T. PRIESTLEY, Rochester, Minn: I would like to ask Dr. Watkins if he will say a word about the nutritional status of these patients.

DR. E. S. BRINTNALL, Iowa City: I enjoyed Dr. Watkins' paper very much. I have had no personal experience with procedures involving pouch replacement of the stomach.

During the past several years in Iowa City, Dr. R. T. Tidrick and I have utilized the Y type of jejunal reconstruction after total removal of the stomach. The jejunal limb, which is led up to the esophagus, is 18 to 24 in. (46 to 61 cm.) in length. The distance between the esophagus and the site of entry of bile and pancreatic juice into the jejunum seems to prevent bile regurgitation into the esophagus. We have had two operative deaths in 22 such procedures.

This Y reconstruction has been so satisfactory functionally that we are reluctant to perform a more complicated type of procedure, although certain other reconstructions do offer the theoretical advantages of substitute reservoirs and reestablishment of continuity of the alimentary tract from esophagus to duodenum.

Our patients with the Y reconstructions have generally shown good weight gains, often 20 to 40 lb. (9 to 18 kg.) after their total gastrectomies. Their food capacity has been better than with jejunal loop reconstructions although probably not as good as with the pouch that Dr. Watkins described. The patients are able to take three main meals a day, but most of them require interval feedings to maintain an adequate food intake. They utilize protein and carbohydrate very well. They utilize fat satisfactorily after an initial few weeks' period following operation. No patient has had more than a mild temporary diarrhea, probably related to faulty fat absorption in the early postoperative period. The patients are free of "bile regurgitation," and to us this seems very important because of its apparent relationship to esophagitis.

In the 20 patients surviving this operation there has been one instance of mild stomal stricture which responded to dilatation. In those patients who failed to maintain their weight satisfactorily after the Y reconstruction, recurrent carcinoma has been found.

This discussion is not intended to condemn procedures such as described by Dr. Watkins, but rather to emphasize the satisfactory results which in our experience have followed the Y type of reconstruction.

DR. DAVID H. WATKINS, Denver: The patients that we have had an opportunity to study have all had periods of rather rapid weight gain postoperatively, which they have maintained. I think Dr. Brintnall is entirely correct in that many of the misinterpretations of the functional status of the anastomoses in this particular area are related more to patients who are deteriorating from their basic disease rather than from the type of anastomosis.

I must confess that when we were dissatisfied with the results of subtotal proximal gastrectomy and with the results of the loop esophagojejunostomy with or without the addition of a Braun anastomosis, I was influenced by some of the information that I found available from the early 1900's when the small bowel and the Roux-Y were used to construct the lower segment of an antethoracic esophagoplasty.

There were numerous reports from von Hacker, Marwedel, Heyrovsky, and others, to the effect that it was very difficult to obtain healing between the superior skin tube and the lower segment of the exteriorized, skin-covered jejunum because of recurrent regurgitation which tended to digest the fibrin and interfere with the healing process. I am very interested to hear of Dr. Brintnall's and Dr. Tidrick's experience.

In answer to Dr. Fisher's question, we have not made any careful bacteriological studies of the flora of this transplanted neostomach.

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NATURAL HISTORY OF ANEURYSMS OF THE AORTA

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ANEURYSMS of the aorta have become the latest major target for surgical treatment. The reports of Dubost,[1] Lam,[2] Cooley and DeBakey,[3] and Bahnson [4] have demonstrated that it is surgically feasible to excise an aortic aneurysm and restore the continuity of the aorta in man by means of an arterial homograft of considerable length. Cooley and DeBakey [5] have recently reported that their operative mortality in these patients is now low; consequently, further information concerning the altered morbidity of the disease, as well as the degree to which these patients can be rehabilitated by surgical operations, should soon be available. The immediate benefits from this form of surgical treatment are striking; therefore, physicians and surgeons alike will await with eagerness further reports of long-term follow-up studies upon these patients.

It is also important for physicians and surgeons to know the approximate chances of survival that a patient with an aneurysm of the aorta would have without special surgical treatment. Obviously, unless accurate information concerning the natural outcome of a disease is available, one has no standards by which to evaluate the results of special forms of therapy. Unfortunately, it is difficult to determine the true natural history of a disease like aneurysm of the aorta, which is frequently overlooked during life; one that is not always fatal; one that has several possible causes and whose clinical course differs with each etiologic agent, and one that may cause death in several different ways. Controlled studies on the clinical course of aortic aneurysms have not been reported. This is due, in part at least, to the low incidence of this disease, but it may also be due to lack of special interest in the problem, since, heretofore, we have had no sound dynamic treatment to offer for this serious condition.

In order to eliminate some of the many variables, this study has been limited to aneurysms of the aorta which were studied at autopsy. This limitation helped to reduce errors in diagnosis, reveal asymptomatic and nonfatal aneurysms of the aorta, determine the specific etiology of the aneurysm, ascertain the mechanism of death as it was related to the aneurysm, and give a base-line population for determining the incidence of aortic aneurysms in this part of the country.

Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 19, 1954.

From the Department of Surgery, University of Cincinnati College of Medicine, and the Lucie Rawson Laboratory for Vascular Research, Cincinnati General Hospital.

GENERAL

Method.—The autopsy protocols and clinical records of all patients at the Cincinnati General Hospital with a pathologic diagnosis of aneurysm of the aorta, between the years 1926 and 1952 inclusive, were reviewed. There were 103 dissecting aneurysms; these were excluded from this study. A saccular or fusiform aneurysm was found in 243 subjects out of 17,168 autopsies. This is an incidence of 1.4%.

Etiology.—It was possible to determine the etiology of the aneurysm in 230 patients (Table 1). The aneurysms were then placed in one of four categories, depending upon their relationship to the patient's death. In 13 instances it was impossible to determine whether the aneurysm was or was not of significance in producing death; these were excluded, leaving 230 for analysis.

TABLE 1.—*Etiology of 230 Aneurysms of the Aorta*

	No.	%
Syphilitic	189	82.0
Arteriosclerotic	32	14.0
Syphilitic and arteriosclerotic	3	1.3
Mycotic	5	2.2
Traumatic	1	0.4

TABLE 2.—*Relation of Aneurysm to Cause of Death in All Aortic Aneurysms*

Category	No.	%
I. Fatal	103	45
II. Major contributory	23	10
III. Minor contributory	13	6
IV. Incidental	90	39

Category I is made up of aneurysms which, without doubt, were the primary cause of death. Category II includes cases in which the aneurysm was undoubtedly the greatest contributory cause, although not the sole or primary cause of death. This group, for example, includes patients who died of pneumonia and who were found to have partial tracheal obstruction or widespread compression of the lung by the aneurysm. Category III is made up of instances in which the aneurysm was a contributory cause of death, but of less than major significance. Category IV comprises those aneurysms considered to be "incidental" and having played no part in the patient's death. Most of these aneurysms were small, although some were large. Included in this group is one case in which the aneurysm filled the entire left hemithorax, but the patient died at the age of 83 as the result of an automobile accident. Also included are 10 aneurysms described as "beginning." Perhaps these should have been excluded, but it was considered best to include them, since the diagnosis was listed on the autopsy protocol. Table 2 summarizes the part played by the aneurysm in causing death. From these figures it becomes apparent that 45% of all aortic aneurysms of this series were fatal, and an additional 10% were a major contributing factor to death.

Incidence.—The over-all incidence of aortic aneurysm in this series, exclusive of dissecting aneurysm, was 1.4%. This agrees closely with the average incidence of 1.5% found in nine similar investigations in England and in the United States (Table 3).

TABLE 3.—*Incidence of Aneurysms of the Aorta*

Author	Hospital	Aneurysms		Autopsies, No.
		No.	%	
Bryant, J. H.[6]	Guy's Hospital, London, 1854-1900	325	1.7	18,678
Nunneley, F. P.[7]	St. George's Hospital, London, 1841-1905	166	0.9	17,872
Lemann, I. I.[8]	Charity Hospital, New Orleans, 1905-1914	67	3.3	2,000
Osler, W.[9]	Johns Hopkins Hospital, to 1914	60	2.7	2,200
Lucke, B., and Rea, M. H.[10]	Philadelphia General Hospital, 1867-1916	278	2.3	12,000
	University of Pennsylvania, 1875-1916			
Gernert, E. R.[11]	Louisville City Hospital, to 1923	28	2.6	1,062
Ogden, M. A.[12]	Charity Hospital, New Orleans, 1931-1938	118	1.3	9,000
Ruffin, M.; Castleman, B., and White, P. D.[13]	Massachusetts General Hospital, 1897-1940	68	0.7	9,600
Maniglia, R., and Gregory, J. E.[14]	Hahnemann Hospital, Philadelphia, 1906-1952	101	1.6	6,000
	Total	1,211	1.5	78,412
Cranley, J. J.; Herrmann, L. G., and Preuninger, R. M.	Cincinnati General Hospital, 1926-1952	243	1.4	17,168

TABLE 4.—*Incidence of Syphilitic Aortic Aneurysm*

	Aneurysms, No.	Autopsies, No.	Incidence
1926-1930	60	2,771	1:46
1931-1935	37	3,179	1:86
1936-1940	44	3,496	1:79
1941-1945	29	2,906	1:100
1946-1950	17	3,424	1:201
1951-1952	2	1,392	1:696
Total	189	17,168	

TABLE 5.—*Relation of Aneurysm to Death in All Syphilitic Aneurysms of the Aorta*

Category	No.	%
I. Fatal	92	49
II. Major contributory	22	12
III. Minor contributory	9	5
IV. Incidental	66	34

ANEURYSMS OF THE AORTA DUE TO SYPHILIS

There were 189 aneurysms due to syphilis in the 17,168 autopsies, giving an incidence of 1 in 91 (1.1%). The changing incidence of syphilitic aortic aneurysm during the 27-year period of this study is worth emphasis and is presented in Table 4.

Relationship of Syphilitic Aneurysm to Death.—The syphilitic aneurysms were divided into categories, as were all aneurysms, and the results are shown in Table 5.

Race and Sex.—The race and sex incidence in 189 aortic aneurysms due to syphilis is presented in Table 6.

The incidence of syphilitic aortic aneurysms in the Negro patient is even higher than indicated by Table 6. The true incidence is concealed by the fact that the percentage of Negro patients on whom an autopsy is permitted in this city is disproportionately low. Zeek * has analyzed this problem and has found that in the years 1942-1952, inclusive, Negro subjects accounted for only 31% of the autopsy population, while the Negro hospital population during the same period was 43%.

Age.—The ages at time of death of these patients who died of syphilitic aneurysm (Category I) were studied. The average age of 29 white patients was 51 years, and 52% were under the age of 50 years. The average age of 63 Negro patients was 43 years, and 59% were under the age of 50 years.

TABLE 6.—*Syphilitic Aortic Aneurysms*

Negro			120	64%
	Males	95	79%	
	Females	25	21%	
White			69	36%
	Males	58	84%	
	Females	11	16%	

TABLE 7.—*Site of Syphilitic Aneurysms of Thoracic Aorta*

	No.	%
Ascending	52	31
Ascending and arch	28	17
Aortic arch	50	30
Arch and descending aorta	22	13
Descending aorta	14	9
Total	166	100

Location.—Syphilitic aneurysms were located in the thoracic aorta in 169 patients (89%) and in the abdominal aorta in 20 patients (11%). The precise portion of the thoracic aorta involved could be determined in 166 instances, and these data are presented in Table 7. Where multiple aneurysms were found, the site of the largest or most significant was used. Thus, 91% of the syphilitic aneurysms of the thoracic aorta involved the ascending portion or the arch.

Of the 20 syphilitic abdominal aneurysms, 2 (10%) were located below the renal arteries and 18 (90%) above these arteries. Both of the aneurysms lying below the renal arteries were incidental findings at autopsy (Category IV); they were, however, rather large, one measuring 12 by 6 cm. and the other 7 cm. in diameter. One patient died of coronary occlusion with atherosclerosis. His serologic tests, however, were positive, and both gross and microscopic pathologic changes were consistent with a diagnosis of syphilitic aneurysm. The other patient died of glomerulonephritis, and both gross and microscopic pathologic changes were considered to be definitely syphilitic.

* Zeek, P. M.: Personal communication to the authors (1953).

Size.—In instances in which the precise measurements of the aneurysm were recorded, the greatest diameter of the aneurysm was considered to be representative of its size. Thus, among the syphilitic aneurysms, there were available for analysis 31 aneurysms of the thoracic aorta that had ruptured, 10 aneurysms of the abdominal aorta that had ruptured, 22 aneurysms of the thoracic aorta that caused death by compression of vital structures, and 24 aneurysms which were incidental. There was no statistically significant difference in the mean maximum diameter between any two of these groups or between all the aneurysms of the fatal group (Category I) and those in the incidental group (Category IV).

TABLE 8.—*Fatal Syphilitic Thoracic Aneurysms*

Symptoms	No.	%
Cough	51	73
Dyspnea	49	70
Pain	47	67
Weight loss	26	37
Hemoptysis	20	29
Hoarseness	18	26
Hematemesis	11	16
Signs		
Tracheal tug	31	44
Tracheal deviation	22	31

TABLE 9.—*Avenue of Hemorrhage from Ruptured Syphilitic Aneurysms*

Organ or Structure	Cases	
	No.	%
Esophagus	12	23
Pericardium	8	15
Pleural cavity	8	15
Lung	7	13
Trachea or major bronchi	4	7
Through anterior chest wall	2	4
Into pulmonary artery	2	4
Retroperitoneal space	6	11
Peritoneal cavity	2	4
Superior vena cava	1	2
"Mediastinum"	1	2
Total	53	100

Form.—In 99 instances, the pathologist made a definite statement regarding the type of the aneurysm. Of these, 81 aneurysms were described as saccular and 18 were fusiform.

Analysis of Symptoms in Patients with Fatal Syphilitic Aneurysms.—There were 79 patients with syphilitic thoracic aneurysms that resulted in death. Of these, 70 patients had been able to give information about their symptoms. The symptoms and signs reported in these patients are listed in Table 8. It was impossible to determine the precise location of pain, when it was present, in a sufficient number of patients to make a detailed analysis of any value. It may be mentioned, however, that of the patients in whom pain was the predominant complaint, it was reported as being in the chest in half the cases and in the abdomen or back in approximately 15% of the cases.

Pain was the only symptom of note in the 13 patients with fatal syphilitic abdominal aortic aneurysms. Of the 10 who reported it, 5 indicated that it was in the abdomen, 1 stated that it was in the chest, and 1 mentioned both lumbar regions. The others did not specify the location.

Mechanism of Death, Fatal Syphilitic Aneurysms.—The mechanism of death in fatal aneurysms due to syphilis was rupture in 53 cases (59%, Table 9), and

TABLE 10.—*Compression of Vital Structures by Fatal Syphilitic Aneurysms*

	Cases	
	No.	%
Trachea	11	30.0
Major bronchi	7	19.0
Lung	3	8.0
Pulmonary artery	2	5.0
Innominate or carotid artery	4	11.0
Superior vena cava	1	2.5
Esophagus	3	8.0
Celiac and superior mesenteric artery	1	2.5
Many vital structures of the thorax	5	14.0
Total	37	100.0

TABLE 11.—*Duration of Symptoms in Fatal Syphilitic Thoracic Aneurysms*

Less than 1 day	3	
1-4 wk.	7	
1-12 mo.	31	41 (59%)
1-2 yr.	13	54 (77%)
2-4 yr.	11	
5-10 yr.	3	
15 yr.	1	
25 yr.	1	
Total	70	

TABLE 12.—*Duration of Symptoms in Syphilitic Abdominal Aortic Aneurysms*

Less than 1 day	2
2 days	2
1 wk	1
6 wk	1
6 mo	1
7 wk	1
15 yr	1
Total	9

compression and erosion of vital structures in 37 cases (39%, Table 10). In addition, there was one postoperative death.

Duration of Life from Onset of Symptoms to Death (Syphilitic Aortic Aneurysms).—Two patients were dead on arrival at the hospital. Eleven others were unable to give a history. Table 11 indicates the duration of life from first symptoms to death in 70 of the 79 fatal syphilitic aneurysms of the thoracic aorta. Thus, 59% of the patients died within one year of the onset of symptoms, and 77% died within two years of the initial symptoms.

Table 12 shows the duration of life from the initial symptoms to death in 9 of 13 fatal syphilitic abdominal aortic aneurysms. Three of the 13 patients arrived at the hospital "in extremis," unable to give a history. Eight of the nine patients (89%) reporting symptoms (pain) were dead within seven months of the onset of symptoms, and six of the nine patients (66%) died within six weeks from the time pain was first experienced.

Duration of Life from Diagnosis to Death.—Of the 92 patients who had syphilitic aortic aneurysms, history is lacking for 8. They were either dead on arrival, comatose, or, for some other reason, were unable to give a history and died shortly after admission and before it was possible to establish the diagnosis. In 84 instances it was possible to make an antemortem diagnosis. In 52 cases (62%) the diagnosis was made correctly; in 32 cases (38%) it was made incorrectly. Thus, 44 of the 52 patients in the fatal group (85%) were dead within six months of the diagnosis of aortic aneurysm. On the other hand, it might be said that 46 of the 52 patients (88%) lived over 24 hours after the diagnosis was established and, theoretically, at least, might have been benefited had a method of treatment been available.

TABLE 13.—*Duration of Time from Diagnosis to Death in Syphilitic Aortic Aneurysms*

10 min	2
5-20 hr	4
1- 7 days	18
1- 6 wk	13
2- 6 mo	7
1 yr	4
3-15 yr	4
Total	52

Terminal Episode.—It is frequently supposed that rupture of an aneurysm causes sudden death. As a matter of fact, this it not always true. It might be possible to save some lives if definitive surgical treatment can be instituted even in what is now considered the terminal episode. In 25% of the instances of rupture of a syphilitic thoracic aneurysm, the patient lived over six hours following rupture, and 15% of these patients lived over 24 hours. Death appeared to occur more quickly after rupture of a syphilitic abdominal aneurysm, although the number is too small to be of statistical significance. Three patients lived over 1 hour; one lived 12 hours, and one lived 2 days following rupture.

ARTERIOSCLEROTIC ANEURYSMS OF THE AORTA

There were 32 aortic aneurysms due to arteriosclerosis. This represents 14% of the saccular or fusiform aneurysms in which the diagnosis could be established, and an incidence of one arteriosclerotic aortic aneurysm in 537 autopsies. The relationship of the extent of contribution of the aneurysm to the death of the patient is presented in Table 14. Thus the aneurysm caused death in 25% of the cases but had no significant effect on the patient's life in 75% of the cases.

Race and Sex.—The race and sex incidence of all four categories of arteriosclerotic aneurysms is presented in Table 15.

Age.—The average age at death of the eight patients with fatal arteriosclerotic aneurysms was 62 years, and 88% were over the age of 50 years. When Categories III and IV were added together, it was found that the average age at death for females was 78 years and for males, 71 years. Thus, it would seem that arteriosclerotic aortic aneurysms either kill the patient or do not materially reduce his life span.

Location of Arteriosclerotic Aneurysm.—Arteriosclerotic aneurysms were located in the thoracic aorta in 12 cases (38%) and in the abdominal aorta in 20 cases (62%). The portion of the aorta involved is presented in Table 16.

TABLE 14.—*Relationship to Death in Arteriosclerotic Aortic Aneurysms*

Category	No.
I. Fatal	8
II. Major contributory	0
III. Minor contributory	2
IV. Incidental	22
Total	32

TABLE 15.—*Race and Sex Incidence of All Arteriosclerotic Aneurysms*

White			29	91%
Males	17	53%	..	....
Females	12	38%	..	....
Negro			3	9%
Males	3	9%	..	....
Females	0	....	..	....

TABLE 16.—*Portion of Aorta Involved by Arteriosclerotic Aneurysms*

Thoracic aorta			12	37%
Ascending	2	6%	..	....
Arch and/or descending	10	31%	..	....
Abdominal aorta (all below the renal arteries)			20	63%

Size.—Measurements were recorded for 6 arteriosclerotic aneurysms that proved fatal and for 13 aneurysms that were incidental. These numbers are too small for statistical analysis, but the variability in each group and the overlapping between groups suggest that the difference in the mean maximum diameters would not be significant.

Form.—According to the prosector's report, 16 (45%) of the arteriosclerotic aneurysms were saccular and 9 (36%) were fusiform. The high incidence of saccular aneurysms due to arteriosclerosis was unexpected. Most arteriosclerotic aneurysms are reported in the literature as being fusiform. The discrepancy may be explained by the looseness of the use of the terms. Although, strictly speaking, a saccular aneurysm is defined as a "sac-like arterial dilatation which opens into the artery by an opening that is small compared with the size of the sac," and a fusiform aneurysm is defined as "a spindle-shaped arterial dilatation"

(Dorland, 21st edition), nevertheless, an aneurysm is frequently described as being saccular because it is globular in shape, and a large fusiform aneurysm may be globular.

Symptoms.—Of the eight fatal arteriosclerotic aneurysms, three involved the thoracic aorta. In two of the three instances, the patients complained of pain; two had cough and dyspnea; one had hemoptysis, and one, hematemesis. In one of the three, tracheal tug and tracheal deviation were noted. The five patients with abdominal aneurysms all reported pain. The site of pain was specified as being in the abdomen in two cases, in the chest in one case, in a testis in one case, and in the left thigh in one case.

Mechanism of Death.—Rupture of the aneurysm was the mechanism of death in six of the eight patients (75%) in this group. The hemorrhage was into the retroperitoneal tissues in three cases, and into the esophagus, duodenum, and right pleural cavity in the other three cases. The seventh patient's trachea was compressed by an aneurysm of the arch of the aorta, and he died after bronchoscopy. Possibly, trauma due to the bronchoscope increased the respiratory difficulty by causing tracheal edema. The eighth death occurred two hours postoperatively, following ligation of the aorta.

TABLE 17.—*Duration of Life from Symptoms to Death*

	Patients, No.
1 day	1
2 days	2
2-3 mo	2
1 yr	1
6 yr	1
11 yr	1
Total	8

Duration of Life from Symptoms to Death.—All eight patients with a fatal arteriosclerotic aortic aneurysm gave a history of symptoms. In five of these, the duration of symptoms was less than three months (Table 17).

Diagnosis to Death.—Three of the fatal eight aneurysms were diagnosed during life. One was diagnosed one day before death; one, three years before death, and one, six years before death.

OTHER FATAL ANEURYSMS

In this study, two mycotic and one traumatic fatal aneurysms are included. One of the mycotic aneurysms occurred in a white man 60 years of age. The aneurysm was located in the abdominal aorta and was diagnosed as due to Diplococcus (Pneumococcus) Type 8. The aneurysm was 9 by 7 cm. and compressed the celiac axis and the superior mesenteric artery. Pain in the low back was the chief complaint, but there was also a weight loss of 25 lb. (11 kg.) in two weeks. His terminal episode lasted one day, during which he was in a coma. The other aneurysm of mycotic origin occurred in a Negro woman 60 years of age. This aneurysm was located in the thoracic portion of the aorta, near the diaphragm.

It measured 4 cm. in diameter and brought about death by rupture into the left lung and thorax. The aneurysm appeared to have been caused by infection of the aorta, secondary to a mediastinal abscess. Pain was reported as the chief complaint, being present in the lower left chest for three months. Cough, hemoptysis, and dyspnea were associated symptoms. She reported a weight loss of 50 lb. (23 kg.) in an unstated number of weeks. The trachea was deviated to the left. Hematemesis occurred twice in the final day of life. Her terminal episode came during fluoroscopy.

The fatal traumatic aneurysm included in this study was found in a Negro woman 29 years of age. The aneurysm was located in the abdominal portion of the aorta and it ruptured into the peritoneal cavity. Pain in the epigastrium and back for three weeks were her chief complaints. The terminal episode was hemorrhage from the vagina.

MULTIPLE ANEURYSMS

Of 191 syphilitic aneurysms (including 2 that could not be put into categories), 39 were multiple. There were 30 double aneurysms; 7, triple; 1, quadruple, and 1, quintuple. Thus 20% of the syphilitic aneurysms were multiple.

Of 33 arteriosclerotic aneurysms (including 1 that could not be put into a category), there were 3 double aneurysms; 4, triple, and 2, quadruple. Thus, 9 (27%) of all arteriosclerotic aneurysms were multiple.

ROENTGEN-RAY DIAGNOSIS

The roentgenogram provided the most accurate means of establishing the diagnosis of aortic aneurysms. Of the 51 patients with a fatal or major contributory aneurysm who were studied by x-ray, the aneurysm was detected in 44 cases (86%). There were 22 patients with a minor contributory or incidental aneurysm who were studied roentgenologically, and in 15 of the cases (68%) the aneurysm was noted.

Erosion of the vertebrae was found in 29 autopsies in the entire series. The aneurysm producing erosion was due to syphilis in 24 instances (18 in the thoracic aorta and 6 in the abdominal aorta). In two instances, it was due to arteriosclerosis (both thoracic aorta); two were mycotic (one thoracic, one abdominal); and one was traumatic (abdominal). Of the 29 proved instances of erosion of the vertebral column, roentgenologic studies were made in 17. The erosion was noted by the roentgenologist in 6 of the 17 cases (35%).

COMMENT

Of 189 patients with an aortic aneurysm due to syphilis, death was certainly due to the aneurysm in 49% of the cases and most probably due to the aneurysm in an additional 12% of the cases. These percentages have a high degree of statistical value, due to the large number of patients and to the fact that all were studied at autopsy. Since there were only 32 proved instances of aortic aneurysm due to arteriosclerosis, one cannot be certain that the mortality rate of 25% would hold if a larger series were available for study. Indeed, this low rate was unexpected, and prompted a study of the literature in order to test its

validity; unfortunately, little could be found to confirm or refute these findings. Clinical reports are not conclusive because of the fact that the diagnosis cannot always be positively established during life; and similarly, the cause of death, however probable, cannot be established definitely without a postmortem examination. While there are many excellent reports of aortic aneurysms proved by autopsy, few authors considered those aneurysms due to syphilis separately from those due to arteriosclerosis, and no similar report in which the number of fatal arteriosclerotic aortic aneurysms are schematically related to the nonfatal arteriosclerotic aneurysms could be found. In this series, 24 of the 32 arteriosclerotic aneurysms had little or no effect whatsoever on the patient's clinical course or duration of life. Although the mean maximum diameter of these aneurysms was less than the mean of those that proved fatal, there was considerable overlapping. Furthermore, although the incidental aneurysms (Category IV) included 10 "beginning aneurysms," as mentioned earlier, only 1 of these "beginning aneurysms" was due to arteriosclerosis, 9 of them being due to syphilis. These findings suggest that the diagnosis of an aortic aneurysm is not, in itself, sufficient indication for surgery.

On the other hand, one must not lose sight of the fact that 45% of all aortic aneurysms found in this investigation proved to be fatal, and an additional 10% were most probably fatal. Furthermore, in the fatal cases, death resulted far more rapidly when due to arteriosclerotic aneurysms, which are the problem of today and tomorrow, than when due to syphilitic aneurysms, which appear to be becoming a problem of the past. Of the patients with fatal syphilitic thoracic aneurysms, 59% were dead within 12 months of the onset of symptoms; 89% of the patients with fatal syphilitic abdominal aortic aneyrysms died within 7 months of the onset of symptoms, and 63% of the patients with fatal aortic aneurysms due to arteriosclerosis were dead within 3 months of the onset of symptoms. Thus it seems that the clearest indication of operative treatment is an aortic aneurysm that is producing symptoms.

The problem that remains is how to select for surgical treatment those patients who have an asymptomatic aortic aneurysm that will subsequently prove fatal (and which may do it so rapidly that insufficient time will be available for life-saving measures) from those patients with asymptomatic aortic aneurysms which will not shorten their life span (75% of this series). The size of the aneurysm alone is not a reliable criterion for selecting patients for surgery. As mentioned previously, there was no significant difference in the mean maximum diameters of the fatal and nonfatal syphilitic aneurysms, and, although the number of arteriosclerotic aneurysms available for study was not large enough to draw positive conclusions, there was considerable overlapping of the maximum diameters of the fatal and nonfatal aneurysms. One aneurysm that caused death by massive hemorrhage was reported to be 1.0 cm. in diameter, while many of the incidental aneurysms were quite large. The physician, however, would have to be a little less than human not to be impressed by a very large aneurysm or one that shows an increase in size while under observation. Unfortunately, examination of these autopsy protocols and clinical records failed to reveal an adequate group of criteria that could be used as definite indications for surgical

treatment in patients with asymptomatic aneurysms. It must be emphasized, however, that this entire study was, of necessity, made in retrospect. With increasing awareness of the possibility of successful surgical treatment of aortic aneurysms, it is hoped that criteria will be found to help the surgeon select the proper patients for this definite treatment.

Caution must be exercised in assessing from this study the incidence of aortic aneurysm in the general population. Even though one could estimate that 17 patients, rather than the proved 8, died of an arteriosclerotic aneurysm in the Cincinnati General Hospital during the years under investigation (since it is known that autopsy was done on 47% of all patients who died in this hospital during the years 1926-1952), this gives no indication of the number of persons who died similarly in the community served by this hospital and whose deaths occurred in other hospitals or at home. In like manner, statistics gathered at centers which include surgeons nationally or internationally known to be particularly interested in aneurysms are likely to be heavily weighted by the large number of patients sent to them from great distances.

SUMMARY

During the 27-year period, 1926-1952, inclusive, an aortic aneurysm was found in 1.4% of all autopsies performed at the Cincinnati General Hospital. Forty-five per cent of the aneurysms were the direct cause of death, and an additional 10% were most probably the cause of death. Eighty-two per cent of all aneurysms were due to syphilis and 14% to arteriosclerosis. The incidence of syphilitic aneurysms has declined rapidly since 1940, only 2 being found in 1,395 autopsies during the years 1951 and 1952. The race and sex incidence, the age at death in patients with fatal aneurysms, and the location, size and type of the aneurysms were analyzed. The symptoms and signs, the mechanism of death in fatal cases, as well as the lapse of time from initial symptoms to death and from diagnosis to death, are reported. Sixty-one per cent of the syphilitic aneurysms proved to be certainly or most probably fatal at an average age of 51 years for white patients and 43 years for Negro patients. Twenty-five per cent of the aneurysms due to arteriosclerosis were fatal at an average age of 62 years. Twenty per cent of the patients with a syphilitic aneurysm and 27% of those with an arteriosclerotic aneurysm were found to have multiple aneurysms; however, only the largest or most significant aneurysm was counted in compiling the statistics herein reported.

Dr. Edward A. Gall, Professor of Pathology, of the University of Cincinnati College of Medicine, reviewed the slides and pathologic specimens of aneurysms of doubtful etiology.

DISCUSSION

DR. LOUIS G. HERRMANN, Cincinnati, Ohio: The dynamic treatment of aortic aneurysms is a real surgical challenge, but if we hope to change that challenge into a therapeutic triumph in a high percentage of these seriously ill patients, we must learn more about the natural history of the disease itself. In the Presidential Address this morning, Dr. Priestley also implied that we must be careful not to confuse what is technically possible with what is therapeutically advisable. It is our hope that the studies Dr. Cranley has presented will initiate other studies which will enable us to set up definitive criteria for the surgical management of these vascular lesions.

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REINFORCEMENT OF VASCULAR GRAFTS WITH VIABLE INTESTINAL SEGMENTS

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PATRICK H. SEAY, Ph.D.
KALAMAZOO, MICH.
EDWARD J. HILL, M.D.
AND
FRANK W. PRUST, M.D.
DETROIT

THE USE of vascular grafts has progressed from the experimental surgical laboratory to the operating rooms of the larger hospitals, where replacement of segments of major vessels has become a relatively common procedure. Much of the recent literature has concerned itself with methods of preserving blood vessels, technical procedures, means of reinforcing grafts, and much speculation as to the ultimate outcome of these grafts.

Although the immediate results in the vascular grafts have been very satisfactory, none of the grafts has gone for a sufficiently long period to determine whether or not they will eventually dilate up under the continual pounding of arterial pressure and became aneurysms.

Nabatoff, Touroff, and Gross [1] showed that venous homografts in dogs will dilate in two to four years, since the functioning smooth muscle is dead. It is known that no smooth muscle will function when it is deprived of its nerve and blood supply. Therefore, all blood-vessel grafts must be considered as dead tissue. Touroff demonstrated that venous implants in the arterial tree of animals tend to dilate and form aneurysms after three years. Arterial homografts may last slightly longer. Heterografts thrombose early, but they may survive as long as the homograft if they last through the initial stage.

The vascular grafts being dead when placed in the vascular tree, they are eventually invaded with fibroblasts, and a nonfunctioning fibrous section results. As such, we believe that they will dilate under constant arterial pressure to form aneurysms. This aneurysmal dilatation might be prevented or delayed if the nonfunctioning vascular graft could be reinforced with a living functioning tissue. In our search for such a reinforcing tissue, we selected intestine because of its proximity to the regions where vascular grafts are commonly used and because it contains smooth

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From the Research Department of the Upjohn Company, Kalamazoo, Mich., and the Research Laboratory, The Harper Hospital, Detroit.

muscle in its wall. We have used ileum and jejunum with intact mesenteric vessels to supply vascular grafts with a living functioning smooth muscle layer having the nerve and blood supply of the host.*

PROCEDURE

Healthy dogs weighing 10 to 13 kg. were used in the experiments. Each animal was given a fluid diet for 12 hours before surgery. The anesthetic used was intravenous pentobarbital (Nembutal) sodium, 1 cc. per 2.5 kg. of body weight. The abdomen was shaved, mercocresols (Tincture Mercresin) was applied, and the animal was draped for a laparotomy.

The abdominal cavity was entered through a midline incision extending from the xiphoid to the pubis. The peritoneum lateral to the descending colon was incised, and the colon, small bowel, and kidney were retracted medially, exposing the abdominal aorta and its branches. A segment of the aorta was dissected free from the trifurcation of the aorta cephalad for

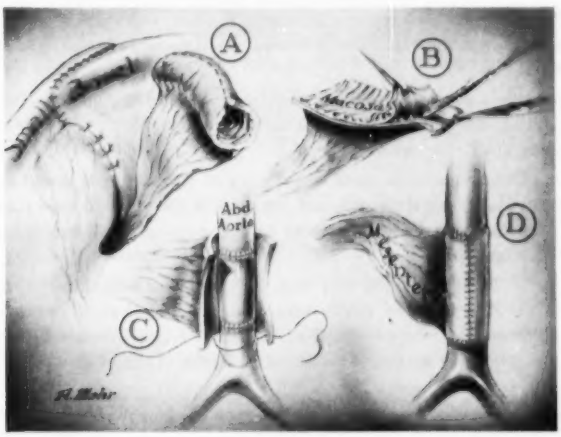

Fig. 1.—*A*, segment of small intestine isolated from the rest of the bowel which has been reanastomosed. Note that the vessels of the isolated segment have been isolated down to the root of the mesentery. *B*, segment of intestine opened at its antimesenteric border, with the mucous membrane being removed. *C*, segment of intestine being placed about the aortic graft. *D*, segment of intestine as it appears after being sutured in place.

approximately 4 to 5 cm. All the tributaries leaving the vessel were ligated and divided between ligatures, thus freeing the abdominal aorta completely from surrounding tissue. A segment of aorta 2.5 cm. long was removed after being occluded above and below with bulldog clamps. This segment was reversed for use as a fresh graft in one series and reinserted, using a running 0000 nonabsorbable surgical (silk) suture. Preserved grafts were used in other series.

At this point it was necessary to relieve the peripheral vasospasm produced by occluding and manipulating the aorta. Thrombosis occurs at the site of the graft if this vasospasm is not relieved. One of two procedures can be used. Tetraethylammonium chloride (Etamon), 2 cc. intramuscularly, can be administered, or a bilateral sympathectomy can be done.

The tetraethylammonium chloride is used to produce a ganglionic block and is administered three times daily until stiffness in the hindlegs disappears. The average duration of treatment required is three to seven days.

If a bilateral sympathectomy is used, the chain on the left is readily removed at the same time that the graft is done, since it is in the operative field. The right side can be removed by incising

* References 2 and 3.

the mesentery lateral to the ascending colon and retracting it medially. Several branches of the inferior vena cava have to be divided between ligatures in some of the animals in order to adequately expose and remove the lumbar sympathetic chain on the right.

To reinforce the graft a 1 to 2 in. (2.5 to 5 cm.) segment of ileum or jejunum supplied by one of the large arcuate arteries was transected. The two ends of the ileum were reunited with a two-layer running silk suture technique, using either a side-to-side or an end-to-end anastomosis. The section to be used as a muscle covering for the graft was freed from the surrounding mesentery down to its root, bleeding points being clamped and ligated as they were encountered. The section of small bowel was incised longitudinally along the antimesenteric border, producing a square or oblong surface. The mucous membrane was dissected off to obtain a smooth muscle layer which contained its own blood and sympathetic nerve supply (Fig. 1). If this was done in the proper plane, the layers separated easily with a minimum of bleeding. A small hole was made in the peritoneum, which had been placed near the graft at the base of the mesentery, where it would not endanger the blood supply of the transplant. The bowel, denuded of its mucosal layer, was passed through this hole and placed about the blood-vessel graft. It was trimmed to fit snugly about the aortic graft, sutured in place with running silk sutures, and both ends were anchored to intact aorta. The peritoneal incisions were closed, and the abdomen was closed in layers.

Picrotoxin was given postoperatively to stimulate the animals. They received 250 to 500 cc. of 5% dextrose during the first 24 hours after surgery, and 400,000 to 800,000 units of penicillin was given intramuscularly for several days.

The blood-vessel grafts used in these series were of several types, and various methods of storage were employed. In one series we used segments of the animal's own aorta. The segment was completely reversed before it was replaced to insure complete destruction of the blood and nerve supply.

In another series the grafts used had been preserved in a modified Tyrode solution, as described by Gross.[4] A few frozen grafts were used. This method of storage proved unsatisfactory unless the vessels were used within a very short time. Crystals form within the cells and increase in size until they develop throughout all layers of the graft with a laceration of the tissues.

Lyophilization was the final method of preservation used. From our viewpoint this proved the most satisfactory method.

RESULTS

A series of 10 animals was prepared with each type of blood-vessel graft, plus an additional series of 10 control animals.

In the series in which the animal's own segment of aorta was reversed and reinforced with small bowel, none has shown dilatation after two years. However, the control animals have shown the same results when the blood-vessel graft was not reinforced with intestinal segment. The animals have not been observed long enough to permit any conclusions as to the merits of the intestinal reinforcing layer.

Animals with preserved human aortas which were reinforced with viable intestinal segments have survived up to one year with no evidence of dilatation.

The intestinal segments have been used in some animals several months after the vascular graft was inserted. The results have convinced us that the reinforcement of a vascular graft with an intestinal segment can be done as a two-stage procedure as well as a single operation. This may provide a means of treating vascular grafts which show a tendency to distend several years after they are inserted.

For direct observation of the grafts we did laparotomy on the animals rather than angiography. The effects of several drugs were studied at the time of laparot-

omy. The observations are shown in the Table. The drugs were injected into the tongue vein of the anesthetized animal. Segments of ileum and jejunum were spread out on a moist towel to demonstrate the mesenteric blood vessels and the intestinal musculature.

When 10 mg. methacholine (Mecholyl) chloride was injected, there was a spotty blanching of the intestine due to contraction of the longitudinal muscle fibers. There was no noticeable contraction of the circular muscle in the intestine, and no change was noted in the caliber of the mesenteric artery supplying the exposed segment.

The injection of 0.25 mg. of methscopolamine (Pamine) bromide produced a very pronounced reddening of the bowel, caused by the engorgement of the small blood vessels in the bowel wall itself. The longitudinal and circular fibers relaxed, and there was no change in the caliber of the mesenteric artery.

A blanching of the bowel was produced by the injection of 100 mg. of tetraethylammonium chloride, and there was a marked contraction of the circular muscle

Drug Effects on Smooth Musculature of Intestine and Mesenteric Arteries

		Ileal and Jejunal Muscle Fibers		Circular Muscle of Mesentery Artery
	Color	Longitudinal	Circular	
Methacholine chloride, 10 mg.....	Blanched	Contraction	No reaction	No reaction
Methscopolamine bromide, 0.25 mg....	Redness	Relaxation	Relaxation	No reaction
Tetraethylammonium chloride, 100 gm.	Tiger-striped, blanched	No reaction	Contraction	No reaction
Epinephrine (1:1,000), 1 ml.....	Unchanged	No reaction	No reaction	Contraction

fibers, giving a "tiger stripe" appearance. There was no apparent contraction of the longitudinal fibers and no change in the caliber of the mesenteric artery.

One cubic centimeter of 1:1000 epinephrine caused a contraction of the longitudinal muscle fibers, so that they appeared similar to the taenia of the large bowel, but there was no contraction of the circular fibers in the bowel wall. Although there was no change in the color of the bowel, the caliber of the mesenteric artery narrowed, indicating a contraction of the smooth musculature in its wall.

The segments of bowel that had been transplanted about the aortic grafts reacted in a similar manner.

These drug effects were produced to demonstrate that the musculature in the transplanted segment of bowel was still viable after two years.

COMMENT

It is well known that damage to large arteries from either the adventitial or the intimal side ultimately causes necrosis of the muscularis. When this muscle layer dies, an aneurysm will probably form, although it may take a matter of years. A spotty necrosis of the muscularis occurs when the adventitial vessels are occluded, as is seen in a syphilitic invasion by spirochetes. If this occurs in the thoracic aorta, a thoracic aortic aneurysm may appear as late as 20 to 30 years after the original insult. This is a clinical manifestation of tertiary or late syphilis.

An abdominal aortic aneurysm appears eventually if the intimal side is damaged by pressure necrosis of the muscle fibers, as in atherosclerosis. It may take 5 to 30 years to occur.

These well-known clinical and pathological entities confirm the fact that fibrous tissue is not adequate replacement for functioning smooth-muscle tissue. This fact was further borne out when cervical arteriovenous fistulae were constructed between the common carotid artery and the internal jugular vein.† Even though the muscularis of the vein was intact, it did not hypertrophy enough to prevent aneurysmal dilatation. The internal jugular vein often dilated up to three or four times its original diameter after several years (Fig. 2). The walls of the vein thickened by fibrosis in the adventitial layers, but this in itself did not prevent aneurysmal dilatation.

As a result of our series, we feel that any blood-vessel graft is inanimate and that organization occurs as it would about any dead tissue. The segment of bowel

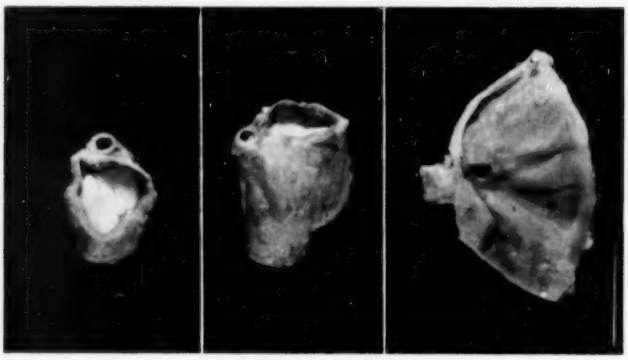

Fig. 2.—A surgically constructed arteriovenous fistula demonstrating the dilatation of the vein occurring after two years.

wrapped around the graft apparently tends to prevent aneurysmal dilatation of the dead intimal graft. More time is needed for thorough evaluation of this procedure. Species difference in the blood supply of the bowel through the mesenteric vessels may prevent its application to humans.

A point of practical importance is that the intestinal segments need not be placed around the blood-vessel grafts at the time the original graft is done. It may be used for reinforcement up to a period of several years if the graft shows a tendency to dilate.

A noteworthy fact which came to light during this investigation is shown in the Table. The longitudinal and circular smooth muscles of the intestine and the smooth muscle in the walls of the mesenteric arteries do not all contract to the same extent to a given stimulus at the same time. This may explain the conflicting results on the effects of these drugs on the intestine when indirect methods of study are used.

† References 5 and 6.

CONCLUSIONS

1. Intestinal segments can be used to reinforce homologous or heterogenous vascular grafts, fresh or preserved, in dogs. In our series dilatation has not occurred up to two years.

2. The smooth muscle of these intestinal segments is viable after two years, as proved by its response to drug stimulation.

3. The longitudinal and circular smooth muscle fibers of the intestine and the circular smooth muscle fibers of the mesenteric artery do not show the traditionally expected similarity in degree of reaction to a given stimulus.

4. The viable intestinal segments need not be placed about the blood-vessel graft when the original surgery is done. They may be used as reinforcements in a second-stage procedure at a later date.

DISCUSSION.

DR. ORMAND JULIAN, Chicago: This work by Dr. Hammer is exceedingly interesting and significant.

The significance stems from the fact that during the past few years we have been placing homologous and autogenous vascular grafts with a degree of abandon that may in the end be unjustified. We have now had venous autographs in place for over three years and homologous arterial grafts in the abdominal aorta for over two years. They have not dilated—but what if they should? We will have aneurysms all over the country in different series.

There have been several attempts to produce autogenous tissue tubes for replacement of blood vessels. Dr. Fell's group, in Chicago, has developed an experimental method to produce a fascial tube that can be implanted. The method described by Dr. Hammer, however, has an advantage, it seems to me, over other methods, in that the graft is a pedicle graft rather than a free graft. It is viable, and it contains the kind of tissue that will withstand constant pressure better than any other, that is, muscle tissue.

Whenever a rigid fascial structure is subjected to stress for long periods of time, it responds by thickening or by gradual elongation. Not so with muscle, which resists the stress by a constant tonic contracture; and if applicable to human subjects in this particular regard, it should be an excellent support for an endothelial-lined tube.

DR. D. E. SZILAGYI, Detroit: It pains me to have to say anything that sounds critical about such ingenious work so beautifully presented as Dr. Hammer's, but the preparation of the intestinal segments described seems, in my opinion, to pose such technical problems as to render them rather difficult of practical application.

Many persons have had misgivings about the future of large arterial grafts, and the question of aneurysmal dilatation constantly arises. Actually there does not seem to be much danger of this happening. Gross has followed aortic homografts of various lengths for seven years, and he has not reported such complications.

It seems to me that if we do have doubts about the future of these grafts, there is a very simple means of reinforcing them by using fascia lata. We use reinforcing strips of fascia lata on occasions when we think the suture line is not as strong as we would like to have it. Larger sheets of fascia lata may also be easily obtained and used to wrap the entire graft.

DR. JOHN M. HAMMER, Detroit: Technically this procedure for anyone who is handling the intestine is not particularly difficult. [Slide] After one has done it a few times it is like handling anything else.

As I said, I have not applied it to humans and do not intend to do so until we find out more about it.

As far as fascia lata is concerned, we feel as does Dr. Julian—that we would prefer to have a functional muscular layer there, to attempt to reduplicate the aorta or the elements of it as nearly as possible.

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THROMBOENDARTERECTOMY IN THE TREATMENT OF LOWER AORTIC OCCLUSION

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THE FACT that the abdominal aorta distal to the renal arteries can be totally occluded by disease and the legs still be viable has been recognized for many years. Reports by Ortner and Griswold,[1] Goodwin and Petrie,[2] and deWolfe and his associates [3] have described cases of this type. Leriche [4] has given his name to the resulting symptom-complex of severe low back and buttock pain on walking, characteristic of high-level intermittant claudication associated with leg ischemia and impotence in the male.

This segmental lower aortic and/or common iliac segmental occlusion is commoner than previously realized, and the increasing awareness of its existence has resulted in the discovery of many previously unrecognized cases. In the past year I have seen 10 such cases and their description and management form the basis of this report.

Segmental occlusion of the distal aorta is frequently associated with varying degrees of involvement of the common iliac arteries, but the main vessels distal to the bifurcation of the common iliacs are usually found to be relatively normal when visualized by aortography. The occluding process is arteriosclerotic in nature and slowly progressive, allowing ample time for the development of an extensive by-passing collateral network. Sudden aortic occlusion over a similar area would have inevitably led to limb gangrene. The length of time that symptoms have been present is frequently surprising, indicating that the process had commenced in early adult life. In two of our patients it was evident from the history that total aortic occlusion had existed unrecognized for 15 years, becoming complete when the patients were about the age of 35. The shortest history was of two years' duration. Three women are included in our series. These patients present themselves, therefore, usually between the ages of 40 and 55, and it is almost invariable that their family histories are replete with many relatives who have died at an early age of heart attacks, strokes, or limb gangrene. This report will not include patients in the older age group, 65 and up, who show evidence of generalized arteriosclerosis. Strangely enough, however, aortic occlusion is not common in the older group; their occlusive disease appears to be most pronounced in the vessels distal to the aortic bifurcation.

SELECTION OF CASES FOR SURGERY

One might well ask why submit a person to operation who has managed to get about with such a condition and be relatively useful for 15 years? The answer is that the severe claudication makes a semi-invalid of the patient, a condition which

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he eventually refuses to tolerate any longer. Secondly, the arteriosclerotic disease continually progresses, and gradual deterioration is inevitable. Thirdly, and most important, is the likelihood of sudden thrombosis of the previously patent arteries distal to the occlusion. This possibility is ever-present due to the arterial disease and to the decreased arterial pressure in the distal arteries. I have seen two patients in the past year who had typical histories of high-level segmental arterial obstruction for many years and who were admitted with limb gangrene following a sudden recent episode of distal arterial thrombosis. This *coup de grâce* followed an attack of pneumonia in one instance and an incidental surgical operation in the other. Consequently, it is the opinion of my colleagues and me that segmental major vessel occlusion should be treated surgically if the following criteria are fulfilled:

1. The aortogram must be a good one, outlining exactly the area of segmental aortic and common iliac obstruction. The x-rays should show patency of the distal vessels to the bifurcation of the popliteal artery. Extensive arteriosclerotic involvement of these distal vessels is a contraindication to operation because it will not be long before occlusive changes occur here also. 2. Plain x-rays of the lower aorta and common iliac arteries should show an absence of calcification. 3. The heart should not reveal evidence of major involvement, and kidney function should be within normal limits. Patients more than 60 years of age are usually unsuitable for this type of reparative surgery due to their generalized disease.

TABLE 1.—*Thromboendarterectomy (Eight Cases)*

Males	5	Females	3	Ages, yr.	41-55
Total occlusion	3-15 yr. previously			Common iliac (right)	1
Aortic and common iliac	6			Partial aortic	1

TYPE OF SURGERY

Two methods of surgical correction of segmental occlusion of major arteries are possible: excision of the occluded segment with replacement by a preserved homologous graft, or removal of the occluding debris and involved intima over the area affected (thromboendarterectomy). I wish to describe our experiences with the latter procedure and discuss the advantages and disadvantages of both methods. Eight patients have been treated by thrombendarterectomy and two by resection and replacement by homologous arterial grafts. In six cases the lower aorta and common iliac arteries were totally occluded in varying degrees; in one case only the right common iliac was segmentally blocked, and in one case partial occlusion of the aorta was present.

THROMBOENDARTERECTOMY

In the eight cases treated by thromboendarterectomy the great vessels were approached by a long left paramedian incision. The small bowel was packed up into the right upper quadrant, or, if the aorta at the level of the renals needed exposure, the small bowel was removed from the abdomen and laid on the right chest in a plastic bag devised by Lahey. The posterior peritoneum was incised

directly over the aorta and iliac vessels and the anterior half of these vessels exposed. The fourth part of the duodenum had to be mobilized and displaced toward the right upper quadrant. The occluded segment was firm, rubbery, and nonpulsatile, and the caliber of the vessel decreased. If the blocked segment was below the renals, the proximal aorta was controlled by a Bethune lung-pedicle clamp. In two cases the thrombotic material in the aorta extended central to the level of the renals, but with only partial occlusion at this level. In these instances the Bethune clamp was placed as usual but not tightened. The proximal aorta was controlled by manual pressure, the assistant using a sponge forceps and

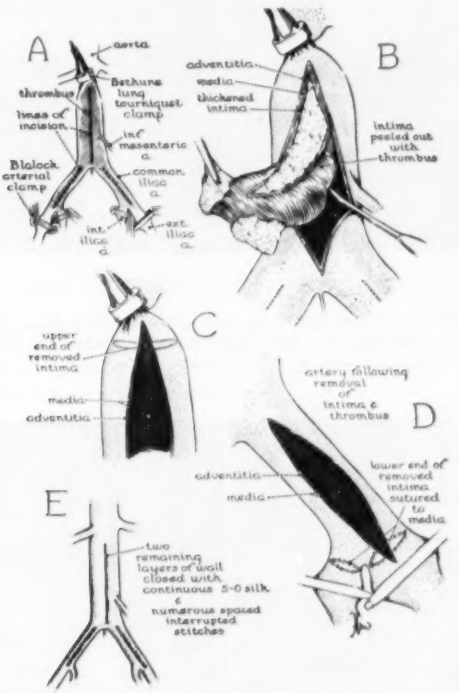

Fig. 1.—Diagrammatic illustration of the technical steps in the operation of aortic and common iliac thromboendarterectomy.

compressing the aorta just distal to the superior mesenteric artery. The incision in the anterior wall of the aorta was carried up to the point at which the left renal vein crossed the aorta. After the proximal aorta was cleaned out, the upper part of the aortic incision was closed immediately to below the level at which the Bethune clamp could be tightened. Care was taken that not more than 25 minutes of renal ischemia resulted. Once kidney circulation had been reestablished, the completion of the aortic and common iliac thromboendarterectomy could be done at leisure because of the previous good collateral circulation.

The one great difficulty and drawback of this operation is the problem of fixation of the lower cut end of the intima. If this lower severed end of intima is

Fig. 2.—Preoperative aortogram showing extensive lower aortic and bilateral common iliac occlusion in a woman aged 41.

Fig. 3.—Postoperative aortogram of the same case as Figure 2, after thromboendarterectomy, showing resumption of patency in the aorta and left common iliac but failure to open the right common iliac.

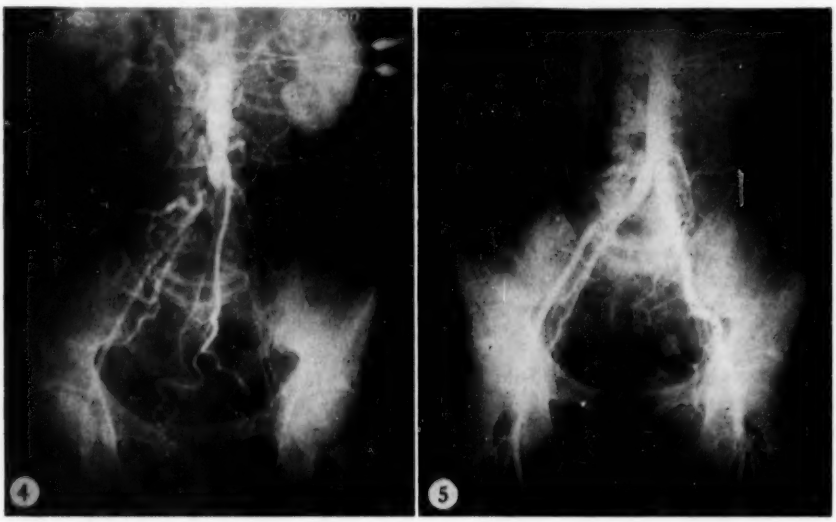

Fig. 4.—Preoperative aortogram showing lower aortic occlusion and poor collateral filling of the left iliac system.

Fig. 5.—Postoperative aortogram of the same case as Figure 4, after thromboendarterectomy, showing patency in all the occluded areas.

not firmly attached to the media, the descending flow of blood tends to dissect the intima from the media, allowing the former to fold in like a flap closing off partially or completely the vessel lumen. Sutures tacking this sclerotic intima to the media do not seem to be adequate, as they apparently pull out. In two patients on whom lower aortic and bilateral common iliac thromboendarterectomy was carried out, complete peripheral pulses returned in one leg but not in the other despite the fact that at the close of the operation pulsations were felt in both external iliac arteries. It is believed that a dissected lower intimal flap was the cause of nonreturn of pulses in that leg. Despite the lack of pulsations in these legs, the temperature and color improved and claudication time was markedly improved, indicating an increased collateral circulation probably through the functioning opposite internal iliac.

Infolding of the lower cut end of the intima as a cause of failure was proved in Case 6, the only case in the series in which the surgical indications were not followed and in which the result was disastrous. This case will be cited in detail because of the operative and postoperative difficulties and points of interest.

Case 6.—B. S. (53-16922), a man, aged 47, was admitted on Oct. 22, 1953, complaining of intermittent claudication in feet and calves for the past seven years. The symptomatology had gradually accentuated to the point where he could walk only one block. On admission his E.C.G. was normal, but the blood sugars were a.c. 116 mg. and p.c. 206 mg. per 100 cc. The oscillometric readings were 1.0 in the right calf and 0.4 in the left. A rise of approximately 6C. occurred in the left foot after lumbar block. Aortogram revealed segmental occlusion of 32 cm. of the left superficial femoral artery and multiple areas of partial occlusion in the right superficial femoral and right common iliac arteries. A large arteriosclerotic plaque was visualized in the lower aorta occluding the lumen about 50%.

Owing to the diffuse nature of the disease, it was thought that removal of the aortic plaque would give the best increase in limb circulation, and this was done on Oct. 31. The aorta was explored and a thromboendarterectomy carried out over the lower 2 in. (5 cm.). The repaired aorta and common iliac arteries were seen to pulsate well at the close of the operation. However, when the drapes were removed, both legs appeared blanched, cold, and cadaveric. The patient was observed for the next three hours, when both legs to the groin became blue, mottled, and colder. It was obvious that very little circulation existed in either leg. Either thrombosis had occurred in the arteries distal to the aorta, or the lower cut end of the intima had formed a valve-like fold completely occluding both common iliacs. The incision was reopened four hours later and the repaired aorta found to be pulsating normally, but pulses in each common iliac were absent. The common iliacs were explored, and the lower cut end of the intima (despite the anchoring sutures inserted at the time of the first operation) had dissected downward and folded inward, producing complete obstruction. The obstructing mass was removed and the intima reanchored. Normal pulsations resulted in the left external iliac artery but not in the right. The right common iliac was reopened and several distal clots removed, but pulsations on the right still remained poorer than on the left. After operation the lividity of the left leg disappeared but was still present in the right foot. Pathological report of the material removed showed marked intimal arteriosclerosis.

The patient's general condition responded rapidly, and both legs improved, the circulation being complete on the left but only to the foot on the right. Loss of sensory and motor power of both legs resulted, and the calf muscles felt tense, painful, and boggy, indicating ischemic muscle changes. The length of time that the blood supply to the legs was almost totally occluded was nine and one-half hours, from the time of application of the aortic clamp, at the first operation, to return of blood flow, following the second operation. His subsequent course has been one of gradual recovery. The bladder paralysis cleared in three weeks, and leg muscles softened rapidly, and return of motor function is slowly taking place in the legs. The hamstrings and posterior tibial group have regained motor function but only partially to the anterior thigh group. The legs are

well vascularized except for dry gangrene of the distal half of four of the five toes on the right foot. This gangrenous process commenced immediately postoperatively. Sensory return to the skin is still limited to the upper two-thirds of each thigh.

The remaining five cases all had complete return of peripheral pulses and complete relief of symptoms and have remained so, with the longest follow-up 12 months and the shortest, 2 weeks. We believe that the two partial successes and the one failure described above could have been obviated by the improved method of intimal fixation which we are now using.

In the above cases anticoagulant therapy was not used in those patients on whom complete immediate return of pulses took place because the volume and force of flow in these major vessels is sufficient to make thrombosis unlikely. Anticoagulants were used in the two partially successful cases and the one failure. Experimental work in our surgical laboratories by Samuels * indicates that intimal regeneration in the denuded vessels is rapid and is complete in 10 days, and, consequently, late thrombosis in the repaired segment is unlikely.

The largest series of this type of operation yet reported is that of Wylie,[5] who describes 38 cases of aortic, iliac, and femoral thromboendarterectomies, in

TABLE 2.—*Results in Eight Cases*

Mortality	0
Return of peripheral pulses with relief of symptoms	5
Return of pulses in one leg only	2
Failure	1

which circulation was completely restored in 25, improved in 4, and unchanged in 2; 3 required amputations, and 4 died.

HOMOLOGOUS GRAFTS

The use of homologous grafts has become an accepted procedure in the past two years in replacing occluded or abnormal arterial segments. This type of graft, like thromboendarterectomy, shows its highest percentage of success when large-caliber arteries are involved. Homologous grafts are indicated in replacing aneurysms of the lower aorta and cases of aortic and iliac artery segmental occlusion in which abnormal calcification occurs in the vessel wall. The difficulties of doing a thromboendarterectomy in the presence of calcific plaques is such as to contraindicate the procedure. The amount of media and adventitia remaining after removal of such a plaque makes the wall dangerously thin, especially if in the suture line.

Because of marked calcification in the area of segmental aortic occlusion, two cases have been treated by resection of the blocked portion with substitution of a preserved homologous graft. In both instances the occluded segment closely approached the renal arteries from below, and thromboendarterectomy had to be performed in the aorta for 1 in. (2.5 cm.) distal to the renal vessels so as to obtain an adequate cuff of vessel on which to apply a clamp and to enable the end-to-end anastomosis to be performed. This complicated the procedure con-

* Samuels, P. B.: To be published.

siderably, prolonging the operating time and adding worries about the strength of the upper suture line, which at the proximal host end consisted only of media and adventitia. Fortunately, nothing untoward has occurred in either case.

COMMENT

In the treatment of segmental occlusion of the lower aorta and/or common iliac arteries in a patient with good patent distal vessels, most authorities agree that surgical repair of the occluded segment is indicated. The previously advocated therapy of bilateral lumbar sympathectomy merely warmed and improved the color of the feet without materially improving the claudication. Whether thromboendarterectomy or excision of the occluded segment with replacement by homologous graft is employed appears at the moment to be a matter of personal opinion and availability of the homograft. There is little doubt that homografts are indicated when considerable calcification exists in the occluded segment, but it is my opinion that thromboendarterectomy is the procedure of choice in the absence of calcification. It is technically simpler and can remove partial occlusions which extend above the renal arteries. Also, the ultimate fate of homologous grafts is still not known, as long-term follow-ups are not yet available. As emphasized above, the only technical difficulty is the fixation of the lower cut intimal edge. However, it would appear that this same difficulty can occur when homologous grafts are used. Julian and his associates have described five cases in which grafts were used. In three of these cases there was failure of return of peripheral pulses in one leg. The intimal thickening of sclerosis is considerable in all cases of this type, and the distal end could easily have pulled away from the distal suture line to give his reported results.

The proportion of good results in such a major undertaking as aortic thromboendarterectomy must be high to justify its performance. Consequently, we feel that the surgical indications, as outlined, must be rigidly followed. The results of localized arterial surgery on those patients with marked generalized arteriosclerosis have not been good, in our hands, and, consequently, we believe that this procedure should not be attempted on patients in the older age group or on those with severe cases of diabetes. Also, our miserable result in the one case of partial aortic obstruction has indicated the inadvisability of the procedure when total aortic obstruction is not present because of the lack of collateral circulation in this type of patient.

It gives a slight degree of comfort to realize that if reocclusion should take place in the previously totally blocked segment after thromboendarterectomy the patient's distal circulation is no worse off because of the well-developed collateral circulation.

SUMMARY AND CONCLUSIONS

Segmental occlusion of the lower aorta and/or common iliac arteries exists more frequently than previously supposed. This condition occurs in the relatively young age group and is recognized by absence or very weak peripheral pulses associated with the symptoms of thigh and buttock claudication and occasionally impotence in the male.

This lesion is usually present for many years before its recognition and is the result of gradual arteriosclerotic narrowing of the aortic lumen. Besides the associated symptoms, its main sequelae is an increased incidence of thrombotic occlusion of the distal arteries and consequent leg gangrene.

Ten cases of this type are discussed, eight of whom were treated by the thromboendarterectomy and two by excision of the occluded area with replacement by homologous arterial grafts. The difficulties of the former operation are discussed, the principal one being the problem of fixation of the lower cut end of the intima.

The results achieved in the eight cases of thromboendarterectomy were complete relief of symptoms in five, return of peripheral circulation in one leg but not in the other in two cases, and failure in one case. There was no mortality or subsequent leg amputation.

It is my opinion that thromboendarterectomy is the procedure of choice in cases of segmental aortic and iliac occlusion when marked calcification of the involved vessels is not present and when the patient is under 60 years of age. The distal vessels should be patent and not severely involved by the arteriosclerotic process, as shown by a good arteriogram.

DISCUSSION

Dr. Ormand Julian, Chicago: I beg your indulgence for discussing another paper, but I find so many common problems between the use of arterial grafts and the thromboendarterectomy as here reported that I wanted to point them out.

The common problem of dissecting aneurysms distal either to an anastomosis or to an area of thromboendarterectomy is the one disturbing feature of either method of treatment. However, there is some technical reason to think that an anastomosis between the diseased segment and a graft might serve to hold the intima in place.

In placing a graft in a defect produced by a resection of the thrombosed aortic bifurcation, first of all in the resection we carry the operation to a portion of the artery in which the disease process is very minor. We can do this without sacrificing anything, and at the time of anastomosis we are able, by an over-and-over suture, to attach the intima of the diseased segment to its wall.

In earlier cases, and still occasionally now, we have made a habit of doing some thromboendarterectomy distal to the resection. I think this is a mistake. More recently, even though there is a good deal of thickening in this region, we have tried to handle it differently than by removing the diseased inner coats.

The different technique now consists of distending the cut end of the vessel with a blunt hemostat or blunt instrument, attempting to enlarge its lumen without removing any material. Occasionally soft tissue between the intima and the media may be taken out during this procedure, leaving the diseased intima as intact as possible. Then, when the sutures are placed, the needle is passed always from the inner side on the recipient's artery to the outside, pushing the intima against media, the opposite direction tending to dislodge it.

These sutures are placed in relatively loosely, and as the arterial pressure distends the circular anastomosis we believe this suture line is drawn up upon, and perhaps may serve successfully to attach the intima.

Of course, very much the same thing could be done, as was pointed out, to suture from the outside the cut end of the intima at the completion of the segment of thromboendarterectomy.

Both of these methods result in a high proportion of reestablishment of circulation. Both of them undoubtedly will have good lasting properties. Perhaps both will be subject to dilatation, the graft, on the one hand, and the thinned-out arterial wall, on the other.

I do not believe this is the time to try to say that one method is better—that the graft is better than the thromboendarterectomy. Both should be continued in use, and at some later time comparison may result in a decision in this regard.

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RETURN TO WORK FOLLOWING OPERATION

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WHEN IS a patient ready to return to work following a surgical operation? It would appear that this question should have been answered many years ago, requiring only revision as newer techniques and adjuvants to healing are added to the surgical armamentarium. The importance from an economic point of view is truly tremendous. Yet, in a careful perusal of the literature, we have been unable to find any discussion of the subject. Furthermore, we have been unsuccessful in finding any extensive published statistics, nor have we been able to procure any unpublished statistics in spite of extensive correspondence with agencies which should be able to furnish them. This is especially surprising in view of the number of times all surgeons record the required partial or total disability times on numerous obligatory insurance forms.

It is apparent that we can readily define the time at which a patient can return to work: A patient can return to work when convalescence has progressed to the stage where the patient is able to carry out a daily occupation without harm to himself and without endangering others working about him in a job which his employer is able to provide. This definition is helpful, but when has the patient's convalescence reached the stage of the definition? And how often is an employer able to provide a job, other than the patient's regular occupation, which might be physically endurable to the patient before he can accomplish his usual activities? These are the two questions which we would seek to answer in this communication.

While there are obvious exceptions, and some of these are observed with sufficient frequency to warrant discussion, we believe that one can categorically define the return-to-work time for certain groups of operative procedures or at least define an average time. The scientific method of determining this time would be to return significantly large series of patients to work after varying intervals of time after specific operations and to observe at which point complications would appear which could be attributable to a too early return to work. This method would be open to criticism, as there would still be many variables. Furthermore, it is somewhat difficult to say which complications are due to a too early return to work. This method is manifestly impossible, as much more than the healing of opposed tissues enters into the problem. Individual endurance and

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fatigability are difficult to evaluate scientifically. Even the sensation of well-being must be considered. This involves emotional factors which may not be inconsiderable after major surgical procedures.

METHOD OF INQUIRY

Lacking such an experimental approach, the question arose as to what method cou'd be used to determine an approximately ideal return-to-work stage.

It seemed feasible to believe that most surgeons must have arrived (if only by the empiric method) at some general average disability periods for diverse types of operations. That these periods would vary depending on the type of work as well as on the surgeons' individual opinions suggested that the diversity of the answers might yield significant findings. By breaking down available statistical data into groups based on the type of operation, it seemed probable that individual differences could be so minimized that the groupings would yield at least minimum-maximum figures which could be a starting point for evaluating current practice. We devised a simple questionnaire based on a series of fairly standardized operative procedures and various types of working conditions (office, light and heavy work, athletic activities, etc.). This questionnaire was sent to 60 eminently qualified surgeons (a group largely composed of teachers of surgery who were also actively practicing their profession).

Since the employer's attitude toward absenteeism and his willingness or ability to furnish suitable light work would largely condition the disability time of the postoperative returnee, it seemed advisable also to send questionnaires to employers. We believed that the employers who would have unquestionably given considerable attention to this problem would be those who hired many employees, who had established an active personnel department and probably a separate medical department. Questionnaires were therefore sent to 50 such corporations, all of which had medical departments approved by the American College of Surgeons.

A third questionnaire was sent to a large number of insurance companies handling disability and casualty insurance, since we thought these would furnish us with valuable statistical information based on actuarial experience.

SUMMARY OF RESULTS OF QUESTIONNAIRES

Surgeons.—Returns from the questionnaires sent to surgeons have been tabulated in Tables 1, 2, and 3.

The variation in return-to-work time is extremely interesting. Although the weighted average time for return to manual labor after an uncomplicated indirect inguinal hernia was approximately eight weeks, some surgeons permitted patients to return to work at four weeks. One who did so commented that he might be somewhat conservative, as he felt certain that many patients could return to work even earlier. One surgeon did not permit return to heavy manual labor for one year after this operation. The same wide variation is seen throughout the accompanying Tables.

If we assume that all of these surgeons are carefully following their postoperative patients and that the results of the operations performed are approximately equal, then we may also assume that the reported results will equal and

be comparable to the results of a theoretical experimental study, as outlined above. We could then conclude that the earliest return-to-work time would be the usual disability time to be allowed for this condition.

Such a conclusion would probably not be valid since the variety of techniques, suture materials, types of patient, and working conditions might vary

TABLE 1.—*Return to Work Following Surgery* *

	Minimum, Wk.	Maximum, Wk.	Average, Wk.
Uncomplicated indirect inguinal hernia (57 reporting)			
Office work	1	5	2.8
Light labor	2	12	4.7
Heavy labor	4	52	8.6
Uncomplicated appendectomy (McBurney incision; 55 reporting)			
Office work	1	4	2
Light labor	1	6	3.1
Heavy labor	2	9	4.5
Pelvic surgery in female (midline incision; 49 reporting)			
Office work	2	6	3.6
Light labor	2	12	5.2
Heavy labor	4	14	7.8
Uncomplicated gastric resection or cholecystectomy (56 reporting)			
Office work	2	12	4.4
Light labor	3	16	6.6
Heavy labor	3	52	9.2
Uncomplicated thoracotomy other than for tuberculosis (33 reporting)			
Office work	2	6	4
Light labor	2	10	5.6
Heavy labor	2	14	7.7

* Although the averages are included as a point of interest, we do not consider the average to be the significant figure. The minimum, however, is significant.

TABLE 2—*Prolongation of Disability for Certain Conditions*

	Affirmative, %	Minimum, Wk.	Maximum, Wk.	Average, Wk.
For bilateral over unilateral herniae	46	½	4	3
For direct over indirect herniae	30	1	8	3.9
For recurrent over primary herniae	58	1	12	4.7
For females	4	1	4	2.5
For diabetes	25	1	4	2.5
For other reasons *	37	1	4	2.5

* Reasons given: infection, malnutrition, recent corticotropin (ACTH) or cortisone therapy, hyperthyroidism, cardiovascular disease, general debility, and psychoneurosis.

TABLE 3.—*Return to Athletic Activities After Appendectomy or Herniorrhaphy*

	Minimum, Wk.	Maximum, Wk.	Average, Wk.
Children and young adults	2	12	4.8
Professional athletes	3	12	6.8

widely enough to vitiate any such assumptions. However, the results of the questionnaire suggest that those surgeons whose patients fall into the categories near maximal disability time are probably unduly delaying return-to-work dates for their patients. This is evident in that exempting the few maximal time limits for the computations brought the average well down toward the minimal time limits.

Parenthetically, it was interesting to note the returns from questionnaires sent to several surgeons working in the same institution. Although it may be assumed that these surgeons dealt with a class of patients with similar physical, economic, and labor backgrounds, there were considerable differences in the return-to-work periods quoted by them. Although not as widely divergent as those in general tables, these differences were still noticeable, more so because of the contiguity of the surgeons.

Table 2 demonstrates that surgeons prolonged disability time for certain types of operations and for certain frequently encountered constitutional states. Table 2 should not be read with relation to Table 1. We noted that some of the surgeons who reported the longer disability times for those conditions listed in Table 2 had reported minimal disability times for the conditions listed in Table 1. Those who had reported maximal disability times for the conditions listed in Table 1 seemed not to report prolonged disability for the graver types of operations, incidentally indicating that these surgeons tempered their conservatism with surgical judgment.

Children and professional athletes tend to be in better-than-average health, and in these cases healing should ordinarily be prompt and noncomplicated. Since we had no basis for determining what would seem a standard disability time for these two special classes, we asked for reports on them in the questionnaire. Table 3 indicates the returns.

Employers.—All of the 50 employers questioned replied to the questionnaire very promptly and many accompanied their replies with long qualifying letters. In 42 instances the questionnaire was answered by the directors of personnel; in 8, by the chief surgeons of the corporations.

Determination of the patient's return-to-work date in the three corporations was made by their medical department regardless of the operating surgeon's opinion. Forty-seven of the corporations asked the operating surgeon to write a letter describing the type of operation performed and the patient's physical fitness to return to work. In spite of these letters, 44 corporations require their own medical departments to make a physical examination of the patient before his return to work.

Only 19, or 38%, of the 50 corporations reported there was always light work available to which a patient could be assigned pending his return to complete health. Six, or 12%, reported they never had light duties available. Eight (16%) sometimes, but not often, had light work. Seventeen (34%) usually (but not always) had light work available.

Personnel managers were asked if they knew what was meant when a surgeon prescribed "light work." Twenty-nine (58%) said they did know. Nineteen (38%) said they would like more information than is usually given. Two (4%) said they had no idea what the surgeon meant by light work. One of these said he felt certain that "the surgeon does not know either."

Asked if they were satisfied with instructions about job limitations given by operating surgeons, 28 (56%) replied they were; 15 (30%) stated they would like more information; 5 (10%) said they were "usually" satisfied, but added many qualifications; 2 (4%) were actively dissatisfied. In answer to what specific suggestions they might offer regarding operating surgeons' instructions,

a constant remark was "better liaison between surgeon and industry" would be most helpful in determining the particular type of work the patient could perform. Several suggested some type of coding of the amount and type of work which could be performed by postoperative returnees.

Some personnel managers thought patients could return to work earlier than surgeons decreed. This was thought to be due possibly to the patient's exaggerating the description of his job to the surgeon in order to get more disability time. Several personnel managers sent operating surgeons a printed form to fill out detailing the type of work, amount of lifting, etc., which the patient could be allowed to do. These forms were used in determining the patient's fitness for various types of work.

In view of the dilemma of large corporations with active personnel and medical departments, one can visualize the difficulties confronting the employer in small industries where the problem must be faced without expert help—or ignored.

Insurance.—All the insurance companies answered our letters promptly, but, surprisingly, not one was able to answer all of the questions. The questions were aimed at determining the length of disability time recorded by insurance companies following standard operative procedures. It was thought that these statistics would yield a general picture of disability time recommended all over the country by a variety of specialists and general practitioners. The intention was to gather information regarding policy-holders, but several companies were able to cite only their experiences with their own employees. One insurance company cooperated by reviewing the individual claims for a year period of two of their policy holders.

However, all of the insurance companies stated they could give us no exact statistical information. This was surprising, considering the number of insurance forms most surgeons are continuously required to fill out, most of which ask specifically for the duration of disability. The information received from these companies was therefore impressionistic rather than statistical. One carrier, for example, felt there was an endemic variation and that patients were returned to work far earlier in some parts of the United States than in others. Parenthetically, we found no such regional differences in the returns made by surgeons.

COMMENT

A review of the information obtained from our questionnaire discloses not enough exact information to warrant definite conclusions. Several interesting ideas suggest themselves, however.

Most surgeons could probably relax their conservative attitudes toward disability time and return patients to work at an earlier date. Correlating the returns of both surgeons and employers, it would seem that surgeons should cooperate more closely with industry to determine the exact nature of the patient's work and whether there is so-called light work to which he can be returned postoperatively. Only close cooperation between the surgeon and the employer will achieve maximum benefit for the patient and employer.

The economic implications of this problem are tremendous. This survey is, unquestionably, merely an exploratory beginning, since the sample has been too small and the results too superficial. It may yet serve, however, as a stimulus to a comprehensive study of an important medicoeconomic problem.

SUMMARY

A preliminary study has been made of the practices of surgeons, employers, and insurance companies regarding postoperative disability time. Results of questionnaires to approximately 60 persons in each of the three groups indicate that (1) there is a wide discrepancy in the attitudes of 60 surgeons toward suitable disability times for a given list of operations and that many surgeons could possibly be less conservative in returning patients to work; (2) that "light work" needs further definition by surgeons and, moreover that an understanding should be reached between employer and surgeon as to whether it is available; (3) that insurance companies have not considered the problem on a statistical basis, and (4) that additional study of this problem is certainly warranted, with close cooperation in such a study between surgeons and representatives of industry.

DISCUSSION

DR. JOHN B. HARTZEL, Detroit: When should a patient return to work following surgery? This problem confronts us almost daily. Dr. Beck's definition is a good one, and I think it will bear repetition: A patient can return to work following surgery when the convalescence has progressed to a stage where the patient is able to carry out his daily occupation without harm to himself and without endangering others, in a job which the employer is able to provide.

Dr. Beck sent these questionnaires to surgeons, to large corporations, and to large insurance companies. The answers, to say the least, certainly afford food for thought. It would seem obvious that the man who returns to his office one week following a herniorrhaphy is not only well on the way to recovery but is anxious to get back on the job.

On the other hand, we are all familiar with the patient who has had an equally easy convalescence but who has amassed some sick time or has several large insurance policies and just does not want to get back to work.

Some of these persons improvise or magnify a complaint which is impossible to ignore and frequently difficult to evaluate. The uncomplicated indirect inguinal herniorrhaphy should be sufficiently healed in two to three weeks to allow a man to sit for a few hours at his desk each day; consequently, if that man stays away from work two or three weeks longer, there must be something other than his herniorrhaphy which keeps him from his job. Maybe two weeks in Florida would seem more interesting.

A man employed in heavy industry needs a few extra weeks of being up and about in order to return to heavy labor, but if he is not well healed and ready to return to work in six weeks, some reason other than the operation must be keeping him away from work, especially if he stays away three months or a year.

In children we would expect the least variation in the convalescent time. The larger surgical procedures should offer wider variations in convalescent time because of real differences in the patient's ability to adjust himself physically and psychologically. In the presence of complications or concurrent disease, it is obvious that extreme variations may occur.

It really gets down to this: Many operations have become well standardized, but to standardize a convalescent, one must also standardize the emotions and desires of the patient, and to date this has not been done. This emphasizes the fact stated many times before, that the practice of surgery is still an art and not an exact science.

SURGERY FOR SOLITARY LESIONS OF THE LUNG

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THE INCREASED interest in thoracic diseases in the past decade has brought to light a relatively new class of patients, those with solitary pulmonary lesions. Probably the greatest factor in bringing many of the asymptomatic patients to treatment has been the use of general survey x-ray films by industry and city health programs. The routine use of admission films of patients entering hospitals for extrapulmonary complaints has added to this group. The general practitioner also has taken an increased interest because of the demand for routine physical examinations in supposedly healthy persons. Finally, many patients with pulmonary lesions demand an exact diagnosis because of the stress of lay publications, another influence which brings persons to their physicians for earlier diagnoses.

In the past it has been the practice of many physicians when confronted with such a single pulmonary lesion to follow a program of "watchful waiting." It soon became apparent that a certain proportion of these lesions were early carcinomas, often primary in nature. Many of these lesions while being watched became symptomatic, and only then were the patients referred for diagnosis and definitive treatment.

Owing to the tremendous strides in thoracic surgery, these solitary lesions now can be safely removed and the diagnosis quickly established. This should prove to be of great value, not only in early malignant tumors but also in other lesions which eventually may cause complications. As early as 1936, Graham and Singer [1] reported on the removal of three solitary lesions in the lung. These lesions were not diagnosed preoperatively, and they were removed in order to make an accurate diagnosis. Since that time, various authors have reported their experience with solitary lesions.* O'Brien and Tuttle [10] reported the first large series in 1948, while a recent report from the Mayo Clinic [11] analyzed a total of 156 patients with solitary lesions, of which 35% were malignant tumors. A sufficient number of reports now are available in the literature to support the correctness of the original contention that preoperative studies infrequently indicate the exact nature of the solitary lesion, and in most cases the correct diagnosis can be established only by tissue biopsy.

Statistics have shown a high incidence of malignant tumors among solitary lesions. This percentage varies in different reports, from 15% to as high as 50%.

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Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 20, 1954.
* References 2 to 9.

It has been pointed out that removal of solitary lesions of the lung will increase the life expectancy in patients with bronchogenic carcinoma. The removal of granulomas of tuberculous or mycotic origin, frequently diagnosed as "tuberculomas" and representing the largest single type of lesion, has been found to be the correct procedure, since such lesions will not respond to chemotherapy.

Over a period of several years, we have observed and treated a series of 70 cases with solitary lesions of the lung, the majority of whom were asymtomatic. Although this series is not large and the majority of these patients were seen in the past two years, certain principles regarding diagnosis and treatment have been established which, in our opinion, need discussion and reemphasis. Particularly, we should like to clarify our present concept of the type of surgery which should be performed for maximum benefit to the patient.

Although many patients deny symptoms on initial interview, careful questioning may reveal hemoptysis, chest pain, slight weight loss, cough, or a change in cough.

TABLE 1.—*Occurrence of Hemoptysis in Seventy Solitary Lesions of the Lung*

	Cases	
	No.	No. with Hemoptysis
Malignant		
Bronchogenic carcinoma	11	2
Metastatic carcinoma	7	1
Metastatic sarcoma	5	4
Lymphosarcoma	2	0
Mesothelioma	1	0
Fibrosarcoma	1	1
Benign		
Granuloma	29	0
Hamartoma	7	2
Bronchogenic cyst	3	0
Fibroma	3	1
Hemangioma	1	1
Total	70	12

In our series of cases, eight patients with malignant lesions and four with benign lesions experienced hemoptysis, a symptom which should be considered as a true objective sign in patients knowing of a tumor in their lung (Table 1). History of previous malignant disease is helpful in suspecting the nature of the solitary density. Because of the location of these lesions in the lung tissue, abnormal physical findings rarely are present over the chest. Search should be made for the presence of lymphadenopathy, abdominal masses, and genitourinary lesions. Laboratory tests should include skin tests for tuberculosis and histoplasmosis, and sputum examinations for bacteria and fungi. Bronchoscopy and bronchography may be carried out but have been of little value in establishing a correct diagnosis. When the history and physical examination suggest an organ system as a possible primary tumor location, specific studies should be carried out, such as upper and lower gastrointestinal study, intravenous pyelography, and endoscopy. In most of the patients, however, the diagnosis will still be in doubt, and direct surgical approach becomes mandatory.

All patients with solitary lesions considered for thoracotomy should have complete pulmonary function studies to provide the surgeon with a knowledge of the patient's respiratory reserve.

MALIGNANT LESIONS

In our series, 38.5%, or 27 patients, were found to have malignant lesions at the time of surgery, nearly half of these being primary bronchogenic carcinomas. Table 2 depicts the pathological diagnosis of our series of solitary pulmonary lesions.

The ages of the 11 patients with bronchogenic carcinoma fell into the usual adult carcinoma group. Symptoms were absent in many; however, a history of weight loss could be obtained in several, and a history of hemoptysis was obtained in three. Physical examination was noncontributory. Bronchoscopy and bronchography failed to reveal any bronchial abnormalities. Examination of bronchial secretions and sputum failed to reveal malignant cells. Thoracotomy was carried out for the purpose of establishing a diagnosis, and the extent of the resection consisted of lobectomy in nine patients and pneumonectomy in two (Table 3). Lobectomy was performed when frozen section of the regional peribronchial or mediastinal lymph nodes failed to reveal the presence of malignant metastasis (Fig. 1). Pneumonectomy was carried

TABLE 2.—*Pathological Diagnosis of Seventy Solitary Lesions of the Lung*

	Cases	
	No.	%
Malignant		
Bronchogenic carcinoma	11	15.7
Metastatic carcinoma	7	10.0
Metastatic sarcoma	5	7.1
Lymphosarcoma	2	2.9
Mesothelioma	1	1.4
Fibrosarcoma	1	1.4
Total	27	38.5
Benign		
Granuloma	29	41.5
Hamartoma	7	10.0
Bronchogenic cyst	3	4.3
Fibroma	3	4.3
Hemangioma	1	1.4
Total	43	61.5

out in the presence of lymph node involvement. In one patient a lobectomy was performed in the presence of mediastinal lymph node metastases because of serious respiratory impairment, as determined by the preoperative pulmonary function studies. In one patient, pneumonectomy was performed when a primary carcinoma was found in the right middle lobe with gross enlargement of the mediastinal lymph nodes. The patient died of bronchopneumonia two days postoperatively, and examination of the permanent sections revealed the lymph nodes to be free of malignant growth. In retrospect, a middle lobectomy should have been performed.

Among the 11 patients with bronchogenic carcinoma was one farmer, aged 48, who was first found to have a solitary lesion on May 9, 1949. Since the patient had no symptoms, no additional examination of his chest was performed until July 13, 1950. Although there was a definite increase in the size of the tumor, there was an additional delay of two years before this patient was referred to the hospital for investigation. The serial x-rays on this patient show gradual increase in the size of the carcinoma (Fig. 2), which was found to be a squamous-cell carcinoma and was removed by lobectomy. The regional lymph nodes were negative, and the patient is well at the present time.

TABLE 3.—*Extent of Surgery Performed in Solitary Lesions of the Lung*

Pathological Diagnosis	Cases, No.	Enucleation	Wedge Excision	Segmental Resection	Lobectomy	Pneumonectomy	Comment
Malignant							
Bronchogenic carcinoma	11	..	..	..	9	2	1 death postoperative due to bronchopneumonia
Metastatic carcinoma	7	1	4	..	1	1	On thoracotomy multiple lesions found in 5 cases
Metastatic sarcoma	5	..	..	..	4	1	3 well-differentiated osteogenic sarcomas
Lymphosarcoma	2	1	..	..	1	..	Both primary in lung
Mesothelioma	1	..	1	..	..	..	Biopsy only
Fibrosarcoma	1	..	..	..	..	..	Very large tumor
Benign							
Granuloma	29	5	9	4	11	..	2 patients subsequently developed positive sputum
Hamartoma	7	6	..	..	1	..	1 lobectomy because of anomalous blood supply
Bronchogenic cyst	3	1	1	1	..	..	No bronchial communication
Fibroma	3	1	2	..	..	..	Superficially located
Hemangioma	1	..	..	..	..	..	Died of pulmonary hemorrhage 4 yr. later
Total	70	15	17	5	28	5	

Metastatic malignant lesions were encountered in 12 patients, 10 of whom gave a history of having had previous surgery for extrathoracic malignant disease. This information was most useful in suspecting the diagnosis of the pulmonary lesions. Hemoptysis was experienced by one of these patients. Five of these lesions were carcinoma metastases from previously resected primary lesions, of the colon in two cases and in the uterus, testes, and ovary in the others. In one case the lesion was later found to originate in a kidney, and in the remaining patient, the primary site is still unknown. In the metastatic carcinoma the lesions were removed by wedge resection in four patients, lobectomy in one, and pneumonectomy in one. The pneumonectomy was performed because of the proximity of the tumor to the hilus. At

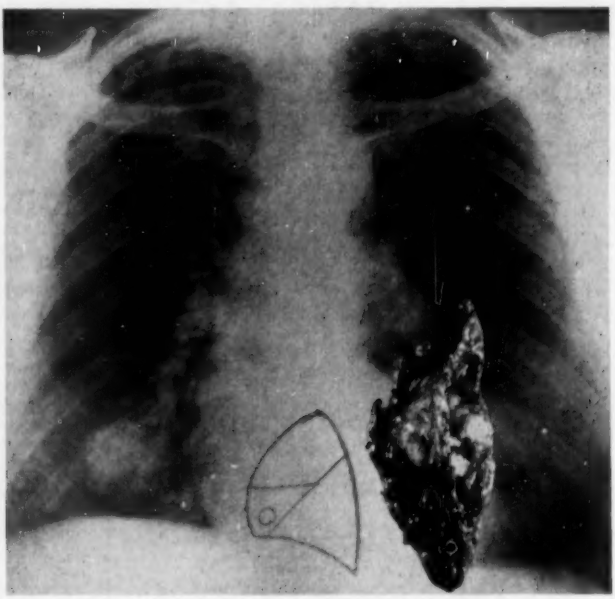

Fig. 1.—Roentgenogram and surgical specimen of bronchogenic carcinoma treated by right middle lobectomy in a 63-year-old white man. The regional lymph nodes were negative for metastases.

the time of surgery it was inaccurately diagnosed as bronchogenic carcinoma on frozen section.

Five cases of metastatic sarcoma were encountered. Four of these gave a history of hemoptysis. The original lesion was osteogenic sarcoma of the femur in two cases, osteogenic sarcoma of the radius in one, fibrosarcoma of the radius in one, and melanosarcoma of the eye in another. In the metastatic sarcomas, four lobectomies were performed (Fig. 3). Pneumonectomy was carried out in the patient with melanosarcoma because of three lesions, two not demonstrated on x-rays and one of which involved the fissure and adjacent lung between the left upper and left lower lobes and technically could not be removed by any other procedure.

In none of these 12 metastatic lesions were peribronchial lymph nodes involved by metastasis. In five cases multiple lesions were found at thoracotomy, only one having been demonstrated by the preoperative x-ray films.

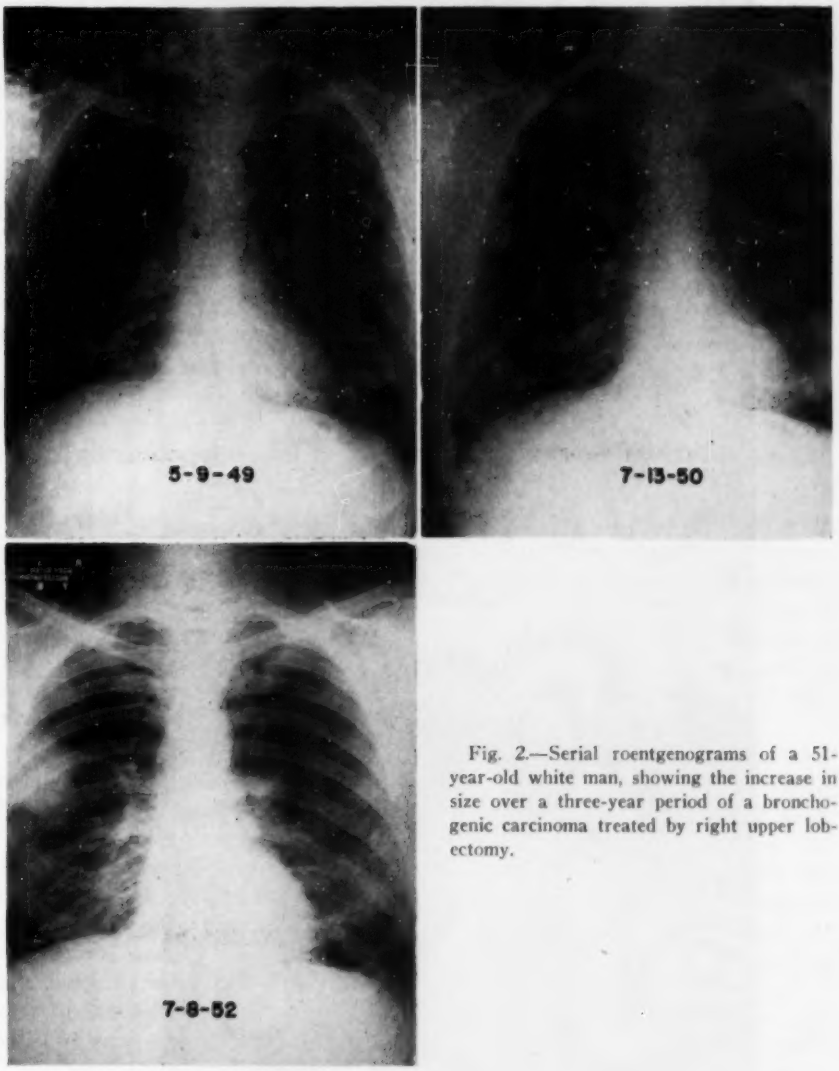

Fig. 2.—Serial roentgenograms of a 51-year-old white man, showing the increase in size over a three-year period of a bronchogenic carcinoma treated by right upper lobectomy.

In this series, two primary lymphosarcomas were removed, one by enucleation and one by lobectomy. The latter has been reported previously.[12] A primary fibrosarcoma was removed by pneumonectomy because of the large size of the tumor. A mesothelioma, considered to be a solitary tumor when originally seen, was found at operation to have extensive spread. Only a biopsy was performed.

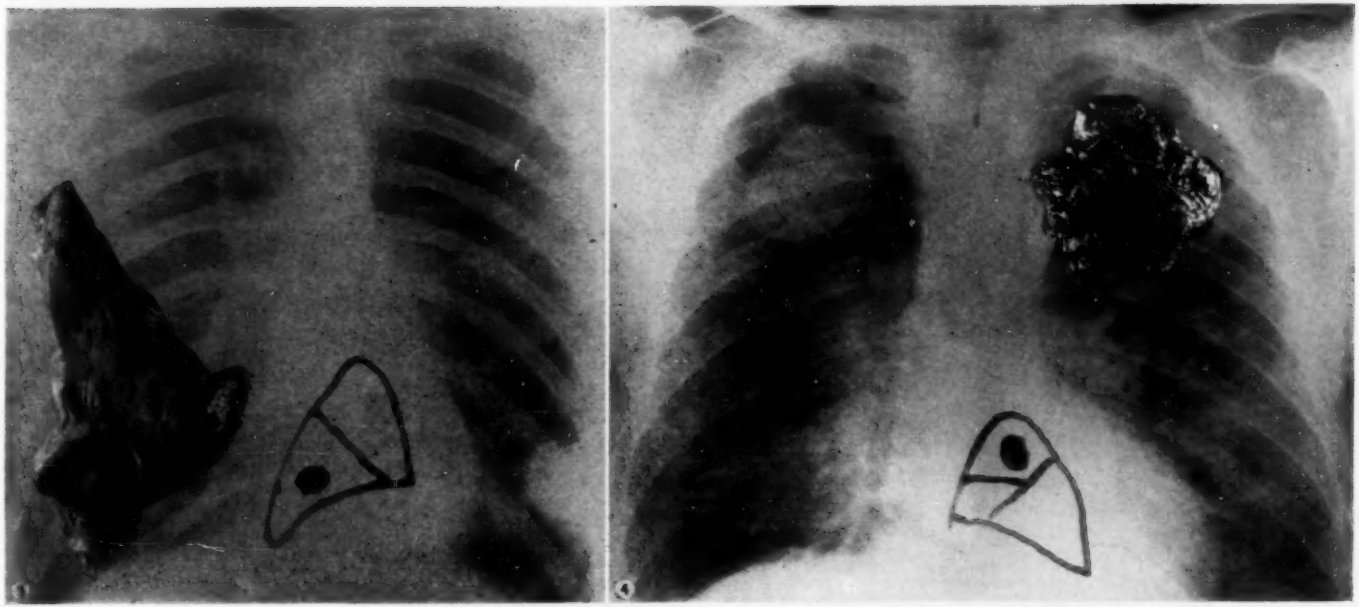

Fig. 3.—Roentgenogram and surgical specimen of an osteogenic sarcoma metastasis treated by lobectomy in a 22-year-old white man. Tumor of the left radius was resected five years previously.

Fig. 4.—Roentgenogram and surgical specimen of a "silicoma" removed by segmental resection in a 64-year-old white man.

BENIGN LESIONS

Sixty-one per cent, or 43, of the 70 patients in this series had benign lesions. These included 29 granulomas, 7 hamartomas, 3 bronchogenic cysts, 3 fibromas, and 1 hemangioma. The granulomas in this series are of particular interest. In 29 lesions considered as granulomas, only 10 had smears and cultures of the surgical specimen. In the preoperative study of these patients, sputum examinations were negative for acid-fast bacilli and fungi. While it is generally considered that such lesions are of tuberculous origin, in none was the etiology established by smear and culture techniques.

In these 29 patients, skin tests revealed negative reaction to first-strength tuberculin in 9 patients, positive reaction in 3. Second-strength tuberculin was positive in three of the former group and was negative in two. Of six patients with positive tuberculin tests, two had positive histoplasmin skin tests and three, negative tests. Two patients had positive histoplasmin tests, while the tuberculin tests were negative. Serial films were not available except in one case, in which a slight increase in size of the lesion was noticed over a period of 10 years.

The x-rays of these patients were inspected for the presence or absence of calcium. Fourteen patients exhibited calcified areas, 15 did not. While the presence of calcification has been considered in the past as an indication of a granulomatous lesion, the fact that only one-half of these patients with granulomas had calcification suggests that this is not a dependable criteria.

Three of these 29 patients at surgery had lesions which were quite hard with irregular borders grossly simulating carcinoma. Preoperative x-ray films gave evidence of a diffuse lesion which with a compatible exposure history suggested silicosis. The surgical excision consisted of a wedge resection, a segmental resection, and a lobectomy (Fig. 4). Palpation of the remainder of the lung revealed the presence of a diffuse pulmonary infiltration which was shown by biopsy and additional studies to be silicosis. Upon sectioning, these areas extruded black, graphite-like fluid. The term "silicoma" is suggested for this entity.

Of the remaining 26 patients, 5 were treated by enucleation (Fig. 5) and 9 by wedge excision. Segmental resection was necessary in two because of the more central location of the granuloma. In 13 patients lobectomy was required. Most of these lobectomies represent the earlier surgical approach to these "tuberculomas." A regrettable complication occurred in one patient when during wedge resection the blood supply to the lobe was unknowingly compromised, necessitating subsequent pneumonectomy. One patient treated by segmental resection and one treated by lobectomy subsequently developed positive sputum for acid-fast bacilli, demonstrating the etiological factor in some of these granulomas. In these two patients the postoperative antituberculous chemotherapy was not adequately administered. The utilization of these drugs must be correlated with the pathological findings of the lesion. Those with soft necrotic areas should receive chemotherapy prophylactically for at least three months.

Nineteen specimens showed caseous necrotic centers upon the cut section, while in seven the lesions was dense throughout without evidence of central caseation. A useful diagnostic feature of these granulomas for the surgeon is the presence of satellite lesions. These were found in 11 cases.

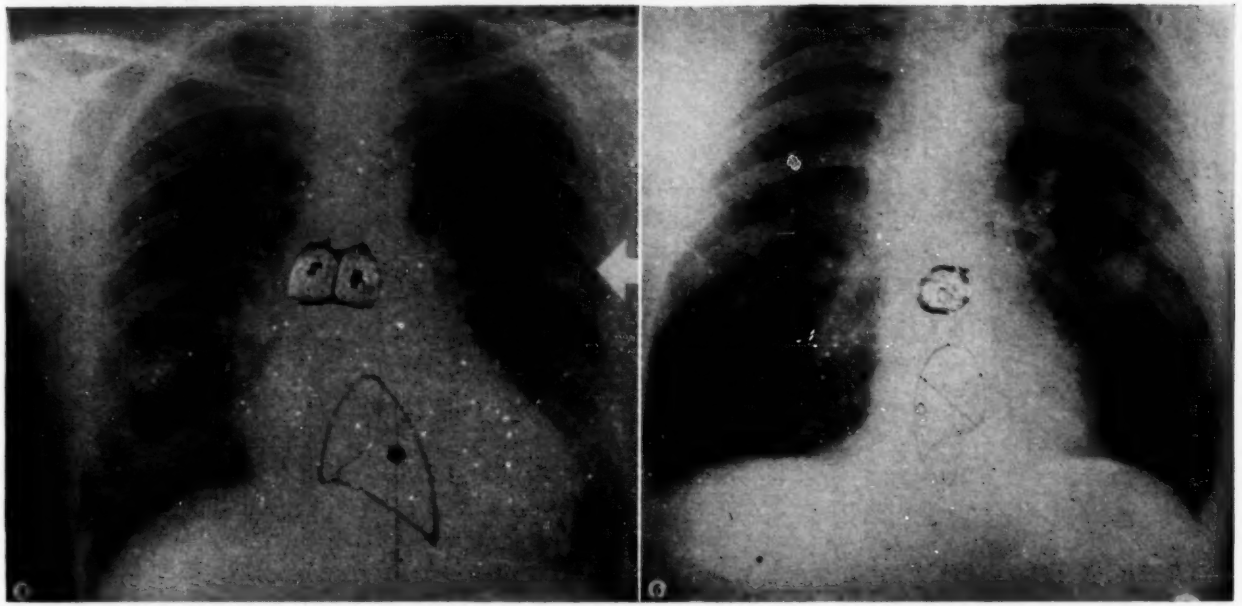

Fig. 5.—Roentgenogram and surgical specimen of a "tuberculoma" removed by enucleation coincident with a mitral commisurotomy in a 57-year-old white woman.

Fig. 6.—Roentgenogram and surgical specimen of a hamartoma removed by enucleation in a 59-year-old white man.

Seven patients, or 10% of the entire group with solitary lesions of the lung, had hamartomas. Hemoptysis was present in two of these patients. One patient had been observed over a period of nine years, during which time the lesion was found to increase in size from 1 to 6 cm. It was only with the appearance of hemoptysis that the patient consented to surgical removal of this tumor. In this patient calcification was present, as it was in another patient with a small hamartoma (Fig. 6).

At the time of thoracotomy the hamartomas were located peripherally and were extremely hard on palpation. Cartilage was the predominant tissue. No additional lesions were found in the hemilateral lung, and adhesions were absent between the visceral and parietal pleura over the lesion. In six patients with hamartomas, enucleation was performed without difficulty. In one patient, enucleation was considered; however, examination of the involved lower lobe showed absence of the pulmonary artery to this lobe with the arterial blood supply coming as two separate branches directly from the thoracic aorta. The venous drainage was into the left auricle. Although the patient did not have any evidence of abnormal shunt or cardiac enlargement, it was felt that lobectomy was indicated in this particular case.

There were three bronchogenic cysts which we have considered of congenital origin. Being solitary without central rarefaction, indicating absence of bronchial communication, these lesions were not diagnosed preoperatively. The finding of clear mucoid material in a smooth, thin-walled cyst arising in the periphery of the lung and producing no distortion of the adjacent lung tissue allowed a diagnosis to be made at the time of thoracotomy. Microscopic sections showed bronchial epithelium and cartilage without evidence of inflammation.

The rate of growth of the bronchogenic cysts is unknown, since no previous x-rays were available for comparison. It is probable that the cysts eventually would have broken into a bronchus with subsequent symptoms, as found in the usual air-filled and infected bronchogenic cysts not included in this series. Local enucleation was performed without difficulty in one patient; wedge resection was used in another, while segmental resection was required in a patient because of the large size of the lesion.

There were three patients with benign fibromas, all of which were removed by local excision. The lesions were located peripherally. Hemoptysis was present in one of these patients; however, it was due to bronchiectasis of the right middle lobe, the fibroma being located in the opposite lung.

The hemangioma occurred in a 13-year old white boy with hemoptysis who had been treated for polycythemia rubra vera over a period of several months. Routine x-ray examination revealed the presence of a solitary lesion in the right lower lobe. The correct diagnosis was suspected, and exploratory thoracotomy revealed the presence of a large arteriovenous fistula. However, numerous other small hemangiomas were noted in the remainder of the lung. A lobectomy was performed, with relief of symptoms. He appeared to be well until one year later when there was recurrence of his symptoms, and angiocardiography showed the presence of multiple arteriovenous fistulae in both lungs. Local ligation of these fistulae in the opposite lung was performed, with relief of symptoms for about nine months. The patient again showed progressive cyanosis and died of a severe pulmonary hemorrhage four years following removal of the original arteriovenous fistula.

COMMENT

It has been suggested that surveys of large population groups would reveal early bronchogenic carcinomas, some of which would present themselves as solitary lesions. Early thoracotomy before metastases should give a higher rate of salvage or possibly cure than in the usual patients presenting themselves with symptomatic carcinoma. This has not been our experience in the 11 patients herein presented. Of three patients with squamous-cell carcinoma, two are alive, one 20 months and the other 9 months after surgery, while one patient was an immediate postoperative death and the only operative death in this entire series. Of three patients with alveolar-cell carcinoma, one is alive 18 months, while the other two died of distant metastases 17 and 3 months, respectively. There was only one patient with adenocarcinoma. Fourteen months after surgery he now presents evidence of local recurrence in the chest wall. Of the four patients with undifferentiated carcinoma, all died within one year of surgery. In summary, 7 of the 11 patients with bronchogenic carcinoma died within 17 months of surgery; 1 has evidence of recurrence, and 3 are alive 20, 18, and 9 months following lobectomy.

On the basis of this small series of early bronchogenic carcinomas appearing as solitary lesions, we cannot share the optimism expressed by others on the excellent results obtained with resection of asymptomatic carcinomas incidentally discovered on x-ray examination. Despite the early recurrence rate in this series, palliation was definitely achieved, and in a larger series of patients the results may be more encouraging.

It is not within the scope of this report to discuss the value of surgery for metastatic lesions of the lung. The over-all results have been discouraging in metastatic lesions of the lung, with the exception of the slow-growing osteogenic sarcomas. The importance of a history of previous surgery for malignant tumors in the diagnosis of solitary lesions cannot be overemphasized. In all of our patients with solitary lesions of the lung and a history of malignant growth, the solitary lesion was found to be of the same cell type as the original tumor, although the interval between the diagnosis and the finding of a solitary lesion was as long as five years. In two patients there was no knowledge of an extrathoracic primary lesion. Subsequently, in one patient a primary tumor of the kidney was found and excised. A metastasis to the thyroid also was removed and excellent palliation achieved. The patient is still alive three years later and is leading an active life as a minister. We shall continue to excise certain solitary metastatic lesions, since there is no question that palliation as well as prolongation of life can be achieved.

Patients with pulmonary carcinoma, whether primary or metastatic, are in the older age group when pulmonary impairment is frequently encountered. This factor must be considered when contemplating extensive pulmonary resection. For this reason, we advocate pulmonary function studies on all patients with solitary lesions of the lung so that at the time of surgery there will be little doubt as to the procedure that can be tolerated by the patient. Marked respiratory invalidism is not justifiable for a palliative procedure.

We have been impressed with the frequency of hemoptysis in patients with solitary pulmonary lesions even though their presenting complaint was not that of

hemoptysis but rather of a tumor in the lung discovered accidently. Eight patients with malignant lesions were found to have hemoptysis, while only two patients with benign lesions, one with associated bronchiectasis, had this symptom.

The finding of solitary lesions on x-ray examination does not eliminate the possibility of multiple lesions in the lung. This is especially true in metastatic carcinoma. It has long been known that soft lesions as large as 1 cm. will not necessarily produce a density on the x-ray film. In all patients with solitary lesions of the lung, lateral and oblique projections should be obtained. Bronchograms have occasionally been of help by indicating distortion of the adjacent bronchial pattern. That growth of a solitary lesion does not necessarily indicate the presence of malignancy is illustrated by enlargement of a hamartoma in one patient over a period of nine years. The pres-

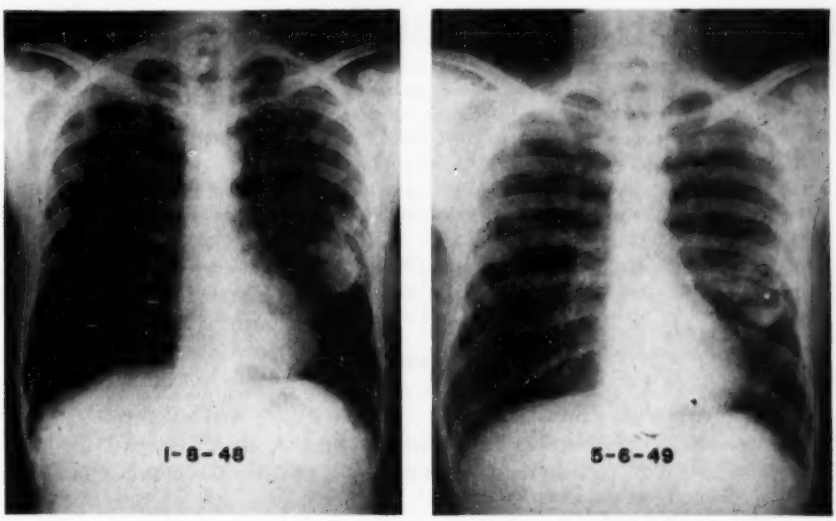

Fig. 7.—Roentgenograms of a "tuberculoma" watched for 10 years in a 42-year-old white man. After excavation the sputum became positive, requiring a lobectomy after prolonged chemotherapy.

ence of calcification does not necessarily mean a tuberculoma or granuloma, since in two osteogenic sarcomas and two hamartomas calcification was present.

Solitary lesions showing central calcification thought to be tuberculomas should be excised, since they may and do break down to produce active pulmonary tuberculosis (Fig. 7).

Two patients, not included in this series, have been observed with solitary lesions suspected to be inactive tuberculomas, who subsequently developed extension of the disease with positive sputum. These patients developed moderately advanced tuberlosis requiring protracted medical and surgical treatment.

SUMMARY AND CONCLUSIONS

Seventy cases of solitary lesions of the lung treated surgically are presented. Of these, 38.5% represented primary or metastatic malignant growths, while 41.5% represented granulomas. The remainder were benign tumors and congenital lesions.

Patients presenting themselves with solitary lesions of the lung should have a pertinent clinical work-up. Search for a primary lesion, within limits, should be performed and a complete cardiopulmonary function evaluation obtained. The patient with a solitary lesion should have a thoracotomy and thorough exploration of the hemithorax. Frozen sections should be performed and benign lesions excised locally. In the presence of malignant growth, frozen section of the regional lymph nodes should be performed. In considering extensive resection for primary or metastatic lesions found at thoracotomy, the pulmonary function of the patient should be considered. Palliation can be achieved in some patients with local excision, and every attempt must be made to conserve pulmonary tissue. On the basis of our experience, we believe solitary lesions of the lung to be a surgical problem.

DISCUSSION

DR. WILLIAM M. TUTTLE, Detroit: We have had this problem of the round lesion for a long time. It is of interest to report that we have now gone back for the last three years and have taken our rounded lesions, which have been diagnosed as granulomata, and have reexamined them. They were diagnosed by our pathologists as tuberculomas. We have restained them with the acid-reduction stain and have found that about 96% are histoplasmosis.

DR. JOHN SPENCER HARTER, Louisville: One frequently hears the statement that if these lesions are showing calcification they do not need surgery. In several cases in the literature, however, and in our personal experience, calcification even in the center of these lesions does not rule out malignancy.

DR. CHARLES V. MECKSTROTH, Columbus, Ohio: Fourteen of the granulomas in our series showed calcification and 15 did not; consequently, we likewise agree that calcification is not a definite criterion for making a diagnosis of tuberculoma or ruling out a diagnosis of malignancy.

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A SUGGESTIVE X-RAY SIGN OF STRANGULATION IN INTESTINAL OBSTRUCTION

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AND
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CLEVELAND

STRANGULATION is a serious threat to life in intestinal obstruction. When this complication develops, immediate diagnosis and surgical intervention are mandatory to avoid mortality. Proper diagnosis of strangulation requires the integration of history, physical examination, laboratory study, and radiologic signs. It is the purpose of this report to draw attention to certain radiologic features occasionally found in intestinal obstruction which are highly suggestive of strangulation although not commonly recognized.

Once a mechanical barrier to the normal passage of fluid and gas along the intestinal tract develops, a sequence of events ensues which produces well-known signs and symptoms. Associated with these are characteristic radiologic findings which result from the accumulation and stratification of gas and fluid in distended loops of intestine. These include "hairpin" turns, "stepladder" arrangement of coils, central distribution of gas and fluid-filled segments of small bowel, and little or no gas distal to the point of obstruction. Great reliance for confirmation of diagnosis is placed on the presence of these findings, and ordinarily these signs are valid confirmation of intestinal obstruction.

However, a review of roentgenograms of the abdomen, in a series of patients who were diagnostic problems and who at operation were proved to have strangulating small bowel obstruction, revealed that in this group the classic findings ordinarily sought were either absent or markedly atypical. Instead, certain common features were found which may be of diagnostic value in strangulating obstructions.

The following cases and roentgenograms illustrate these points.

REPORT OF CASES

CASE 1.—J. D., a 34-year-old white woman, was admitted to the hospital with a six-hour history of abdominal pain, colic, and vomiting. Two months before, an incarcerated inguinal hernia was repaired and a perforation of the ileum was closed. On examination there was exquisite abdominal tenderness with spasm and rebound tenderness. There was a suggestive mass about 8 cm. in diameter in the right lower quadrant. Roentgenograms of the abdomen were made (Fig. 1 *A* and *B*). At operation strangulation of the ileum was found. Resection and lysis of adhesions were carried out.

Drs. Rack and Glazer were introduced by Dr. F. A. Simone.

Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 20, 1954.

From the Departments of Surgery and Radiology, Western Reserve University School of Medicine, at City Hospital.

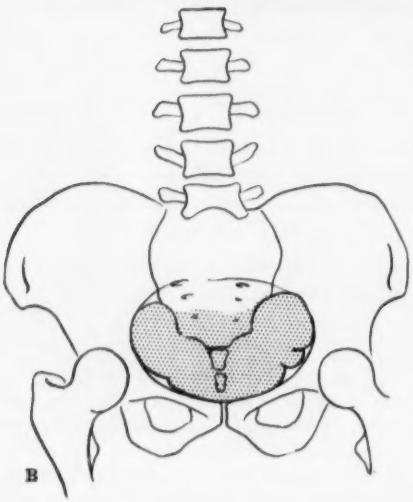

Fig. 1.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals presence of many distended loops of small intestine in mid- and upper abdomen, creating "hairpin" turns. Inspection reveals distinct haziness in pelvis with suggestive polycyclic or scalloped border. At operation this area was found to contain a long segment of necrotic ileum resulting from strangulating adhesions in pelvis. *B*, line drawing of roentgenogram shown in *A*.

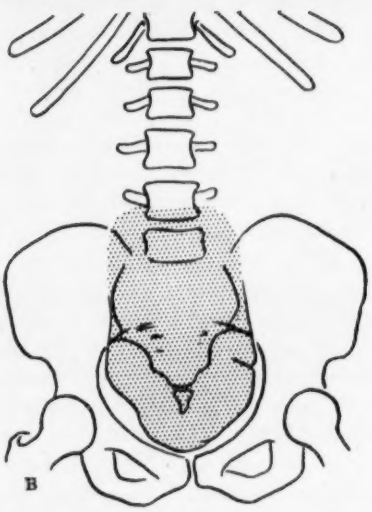

Fig. 2.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals minimal amounts of gas in stomach and large bowel. There is little to suggest intestinal obstruction. Close inspection reveals distinct haziness in lower midabdomen. At operation a necrotic mass of ileum was found bound down in pelvis secondary to a ventral hernia. *B*, line drawing of roentgenogram shown in *A*.

Comment. — Careful study of the roentgenogram reveals the presence of a haziness in the pelvis with a suggestive polycyclic or scalloped border. This represents the mass of necrotic bowel found at operation.

CASE 2.—R. F., a 50-year-old white man, was admitted to the hospital with a three-hour history of epigastric pain, colic, and vomiting. There was exquisite tenderness in the epigastrium and right lower quadrant; in the lower midabdomen there was a semisolid slightly tender mass. Roentgenograms of the abdomen were made (Fig. 2 *A* and *B*). At operation strangulation of the ileum was found in a ventral hernia.

Comment.—The roentgenogram in this case reveals few of the features commonly associated with intestinal obstruction. There is little stratification of gas and fluid and no evidence of "hairpin" turns. However, a haziness is present in the pelvis, representing the mass of necrotic bowel found at operation.

CASE 3.—J. S., a 70-year-old white man, developed epigastric cramping pain while in the tuberculosis pavilion. Examination revealed spasm over the right lower rectus muscle and some rebound tenderness. Roentgenograms of the abdomen were made (Fig. 3 *A* and *B*). At operation torsion of the mesentery of the ileum with strangulation of the ileum was found.

Comment.—Failure to recognize the presence of strangulation in this type of case may result in a fatality. Had emphasis been placed only upon the gas-filled loops in the roentgenograms, a diagnosis of simple obstruction might have been made. The discrete hazy shadow in the pelvis represents necrotic bowel.

CASE 4.—E. P., a 64-year-old white woman, was admitted to the hospital with a history of abdominal cramps, vomiting, and diarrhea of 12 hours' duration. The lower abdomen was tense, tender, and moderately distended. A cystic tender mass was felt in the lower abdomen in the midline. Roentgenograms of the abdomen were made (Fig. 4 *A* and *B*). At operation an adherent band of omentum constricting the base of the mesentery was found causing gangrene of the small bowel.

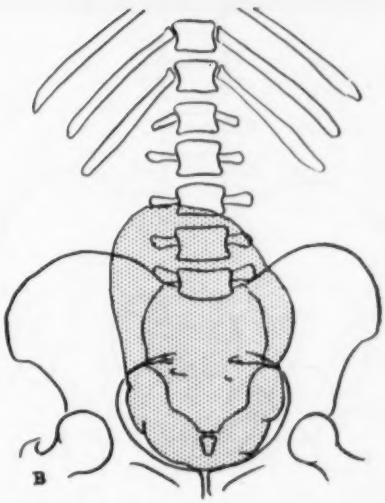

Fig. 3.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals moderate air-filled loops of small intestine in left upper quadrant. In pelvis a well-outlined haziness is seen above dome of bladder and slightly indenting it. At operation this shadow was found to represent necrotic loop of low ileum secondary to torsion of mesentery. *B*, line drawing of roentgenogram shown in *A*.

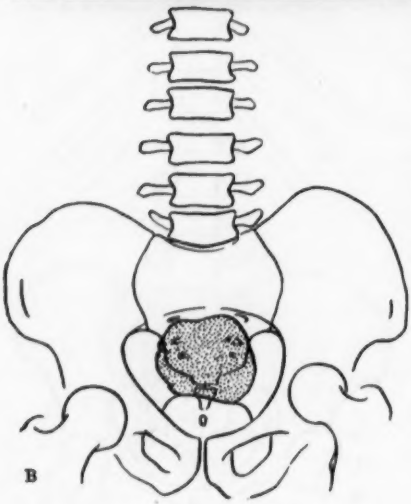

Fig. 4.—*A*, anteroposterior roentgenograms of abdomen made in supine position with iodopyracet injection (Diodrast) outlining bladder in one. Minimal gas is present in a few loops of small intestine. Diffuse haze covers entire lower abdomen. At operation this portion of abdomen was found to contain long segment of necrotic bowel secondary to adhesion constricting mesentery. *B*, line drawing of roentgenogram shown in *A*.

Comment.—The roentgenogram in this case illustrates how little evidence may be present in far-advanced bowel obstruction with strangulation. Except for a few scattered loops with minimal amounts of gas there is no suggestion of intestinal obstruction. The diffuse haziness over the lower abdomen demonstrates the strangulated bowel found at operation.

Case 5.—M. B., a 38-year-old white woman, was admitted to the hospital with a 24-hour history of severe left lower quadrant pain, nausea, and vomiting. Examination revealed diffuse abdominal tenderness with minimal spasm. There was a poorly outlined mass in the left lower quadrant. Roentgenograms of the abdomen were made (Feb. 5 *A* and *B*). At operation the left tube and ovary were found to be twisted around the base of the mesentery, causing strangulation of the small bowel.

Comment.—The abdominal roentgenogram reveals some evidence of intestinal obstruction, but more striking is the soft-tissue shadow with distinct margins in the midlower abdomen, corresponding to the necrotic bowel found at operation.

Case 6.—A. D., a 56-year-old Negro woman, was admitted to the hospital because of cramping midabdominal pain and vomiting of six hours' duration. The abdomen was slightly distended, but there were no peritoneal signs

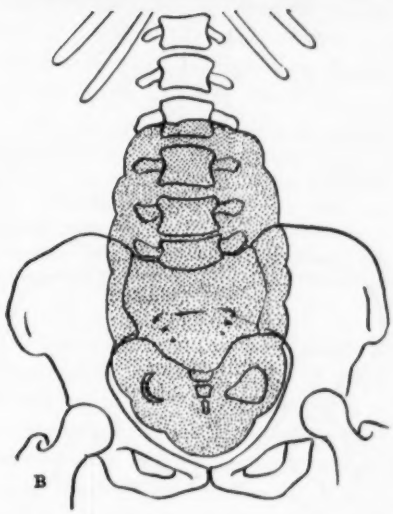

Fig. 5.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals "hairpin" turn in left upper quadrant. In addition, superior and lateral borders of definite soft-tissue mass are well outlined in lower mid-abdomen. At operation it was found that left tube and ovary had twisted around base of mesentery, causing strangulation of small bowel. *B*, line drawing of roentgenogram shown in *A*.

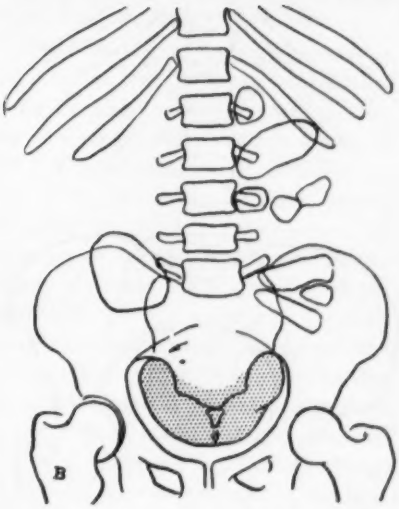

Fig. 6.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals sporadic moderately distended loops mostly of small bowel. In pelvis there is mass with ground-glass appearance and polycyclic border. At operation this mass was found to be necrotic small intestine secondary to volvulus. *B*, line drawing of roentgenogram shown in *A*.

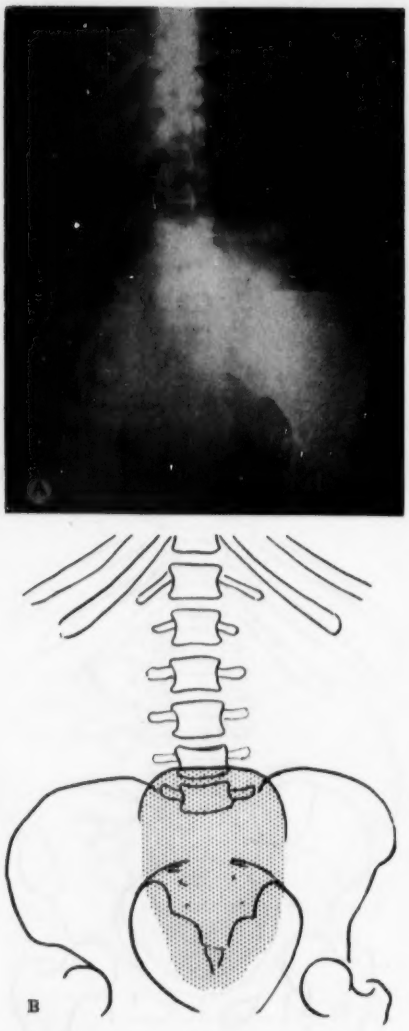

Fig. 7.—*A*, anteroposterior roentgenogram of abdomen made in supine position reveals one "hairpin" turn in midabdomen and diffuse haziness in lower midabdomen with slight suggestion of definition superiorly. Obvious gas is present low in rectum and in left colon. At operation, mass in pelvis was found to be mass of necrotic small bowel; strangulation was secondary to adhesions. *B*, line drawing of roentgenogram shown in *A*.

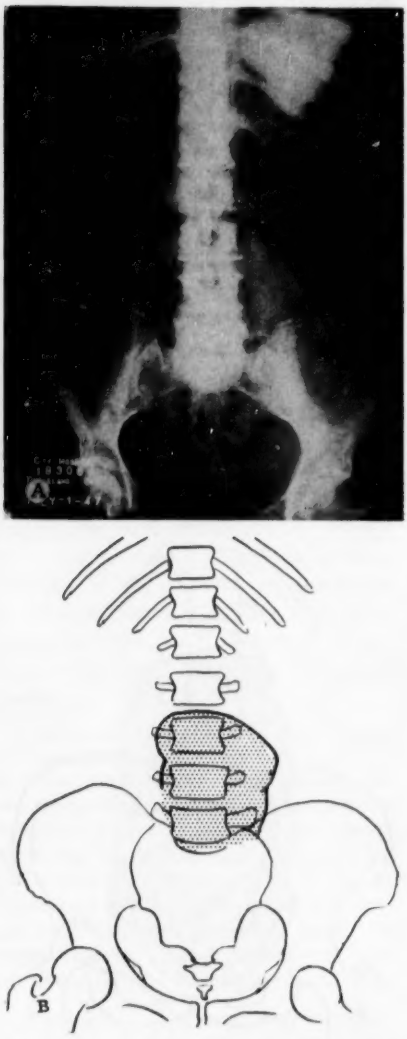

Fig. 8.—*A*, anteroposterior roentgenogram of abdomen in supine position shows soft-tissue density overlying lumbar vertebrae and extending to left, with one border showing polycyclic or scalloped marking. At operation this density was found to represent necrotic ileum in hernial sac. *B*, line drawing of roentgenogram shown in *A*.

or masses. Roentgenograms of the abdomen were made (Fig. 6 *A* and *B*). At operation a volvulus of the small bowel with necrosis was found.

Comment.—The roentgenogram in this case illustrates the presence of a ground-glass-appearing mass with a polycyclic or scalloped border corresponding to the mass of necrotic bowel found at operation.

CASE 7.—M. P., a 40-year-old Negro woman, was admitted to the hospital with a seven-day history of abdominal pain, vomiting, and obstipation. Examination revealed an obese abdomen without evidence of spasm or tenderness. There was a vague mass in the left lower quadrant. Abdominal roentgenograms were made (Fig. 7 *A* and *B*). At operation necrosis of the small bowel secondary to strangulating adhesions was found.

Comment.—The roentgenogram presents little distention of the intestine, but there is a diffuse haze in the lower abdomen and pelvis corresponding to the necrotic bowel found at operation.

CASE 8.—L. H., a 61-year-old white woman, was admitted to the hospital because of nausea and vomiting of three days' duration. Examination revealed an incisional hernia with few signs of peritoneal irritation. Abdominal roentgenograms were obtained. At operation 15 cm. of ileum was found to be necrotic in the hernial sac.

Comment.—The roentgenogram shows considerable distention of small bowel, but, in addition, corresponding to the necrotic bowel found at operation, is a diffuse haze in the lower abdomen and pelvis with one border showing a polycyclic or scalloped marking.

COMMENT

An attempt has been made to illustrate by a series of roentgenograms of the abdomen taken in the supine position in cases of intestinal obstruction that the classic roentgen findings may be markedly distorted or absent in the presence of a strangulating type of obstruction. Even in their absence, however, as illustrated by the patients described, one sign, not usually appreciated, may be present which is highly indicative of a strangulating type of obstruction. Demonstrated in variable degree in the roentgenograms described, it is the presence of a definite localized shadow or haze with a ground-glass appearance on the supine roentgenogram of the abdomen corresponding anatomically to the mass of strangulated bowel. In some instances this finding may present a definite polycyclic or scalloped border. Gas-distended loops of small intestine may or may not be observed with this finding. Frimann-Dahl [1] has made note of this fact in the past, and a review of abdominal roentgenograms in 100 consecutive cases of nonstrangulating small bowel obstruction failed to reveal the latter finding in any case.

Most likely this finding develops as the result of changes in the permeability of the intestinal vessels and wall secondary to strangulation. The appearance of the abdominal roentgenogram in obstruction is determined by several factors, including the level of obstruction, the duration of the obstruction, and the integrity of the blood supply. In the normal adult little gas is visualized in the small bowel. Either it is empty, or the gas and fluid mixtures are so well emulsified that no stratification is present. Obstruction to the normal passage of gas, however, produces stasis and a physical change in the character and volume of the mixture; the so-called typical x-ray appearance of intestinal obstruction develops. In strangulation with increased permeability, "sweating" both into the lumen of the bowel and into the peritoneal cavity occurs. The loops involved quickly fill with fluid and become layered one upon another. As the process continues, all demarcation between adjacent loops is

lost except in peripheral areas, where occasionally the "hairpin" loops of intestine, now completely filled with fluid or blood may present a polycyclic or scalloped border (Fig. 9). When strangulation develops quickly, before much air is swallowed or trapped proximal to the obstruction, very little gas or distention may develop subsequently, because the nonstrangulated segments of intestine invariably develop some adynamic ileus and the ability of the intestine to propel gas and fluid toward the obstructing point is lost.

Other entities which may yield a homogeneous soft-tissue density within the abdomen on roentgen examination similar to the one described in strangulating obstruction are related to three processes: (*a*) enlargement of viscera, such as kidney, spleen, ovary, bladder, or uterus; (*b*) paravisceral processes, such as loculated collection of fluid, abcesses, and omental thickening, and (*c*) new growths on nonvisceral origin, such as retroperitoneal tumors. Clinical features will usually allow differentiation of these conditions from intestinal obstruction.

CONCLUSION

The diagnosis of intestinal obstruction should be a clinical one, with abdominal roentgenograms serving merely to support the diagnosis. The differentiation

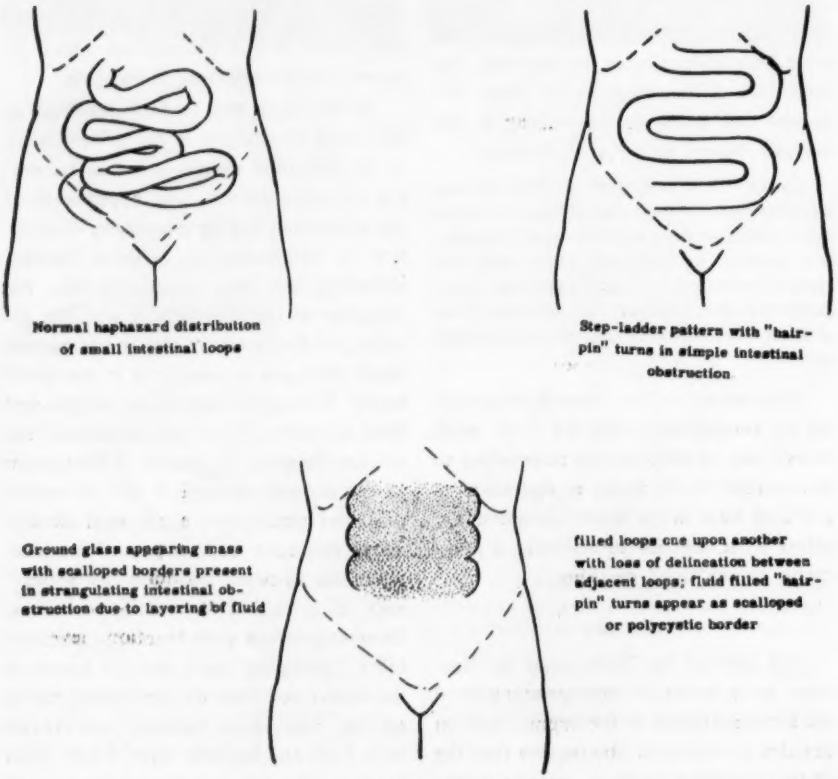
Normal haphazard distribution of small intestinal loops
Step-ladder pattern with "hairpin" turns in simple intestinal obstruction
Ground glass appearing mass with scalloped borders present in strangulating intestinal obstruction due to layering of fluid
filled loops one upon another with loss of delineation between adjacent loops; fluid filled "hairpin" turns appear as scalloped or polycystic border

Fig. 9.—Diagrammatic representation of development of abdominal roentgenogram in simple and in strangulating intestinal obstruction.

between simple and strangulating obstruction, likewise, must be a clinical one based on signs of peritoneal irritation, fever, leucocytosis, increasing pulse rate, and so on. However, the absence of the classic roentgenographic findings of distended loops of small bowel should not be grounds for delaying operation. Careful review of the films should be undertaken in search of the finding described. When it is found, either with or without associated distended loops, strangulation should be strongly suspected and emergency surgery planned.

DISCUSSION

Dr. S. P. Harbison, Pittsburgh: I do not suppose there is any condition which we face in surgery that taxes the judgment and the patience of the surgeon more than does small bowel obstruction, trying to get a patient through a temporary episode but not wanting to allow that patient to go on to strangulation.

Certainly earlier operation is being done and advocated for small bowel obstruction, but we still find cases in which strangulation may occur.

Anything that will help us to differentiate the cases in which there may be definite doubt as to what is going on is exceedingly valuable, and this sign may be partly the answer. I intend to go home and review my own cases in terms of whether or not this sign was present. It is new to me. I feel that it may become a definite adjunct to the handling of these difficult cases.

I should like to ask Dr. Rack whether he found any roentgenograms in this series in which the signs were not present and yet strangulation was found, because I think it is important that we know whether or not the sign is always positive in strangulation.

Dr. F. J. Rack, Cleveland: I want to thank Dr. Harbison for discussing our paper. Yes, we have seen cases of strangulation that did not present this sign. It is just another sign that should be looked for. The x-rays alone should never be used to determine the treatment of the patient. Examination of the patient's abdomen, search for peritoneal signs of irritation, leucocytosis, tachycardia, and so on, must determine, in the final analysis, the diagnosis and treatment.

Certainly I do not want to leave the impression that patients who do not present this sign do not have strangulation.

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CANCER OF THE LARGE BOWEL

A Follow-Up Study of Four Hundred and Twenty Cases from a Private, a Charity, and a Veterans Hospital

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DETROIT

THE DISCREPANCY in results obtained in the treatment of cancer as reported by various groups has been pointed out in the past by Saltzstein [1] and Ewing.[2] That such wide differences still exist is suggested by Table 1. These variations are disconcerting despite obvious explanations such as differing economic strata of the patients, charity versus private care, and private clinic surgery as against that done by many surgeons in a general hospital. To add to the confusion, there are no generally accepted definitions of "five-year survival rates" and "resectability rates," and the bleak or brilliant results reported may depend upon a choice of definition. Buser, Kirsner, and Palmer [5] demonstrated this fact very well in 1950. By varying their method of computation the five-year survival rate could be brought as low as 25.6% or raised as high as 57%. To compare one's results with others reported is difficult.

To investigate the average management of cancer of the large bowel in this area and to determine the end-results obtained, we have studied 420 consecutive, histologically proved cases of this disease in three of our large hospitals.

Two hundred and eighteen cases have been followed for five years. Of these, 71 cases were from a charity and 147 cases from a private general hospital. The veterans hospital patients have been followed for a much shorter period and are included in this series for reasons which will appear later. The locations of the lesions conformed to the generally known incidence of cancer of the large bowel.* Our patients varied in age from 14 to 85 years, and the number in each decade is represented in Table 3.

The greatest incidence in the veterans group was the sixth decade, in the private group in the seventh decade, and in the charity group in the eighth decade. As in other series, 8.1% of our cases occurred under the age of 40. Seventeen per cent of our patients were over 70. There were 28% aged in the charity group, and three-fourths of them were admitted with an acute surgical abdomen. Of

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From the Departments of Surgery, Wayne University College of Medicine; Detroit Receiving Hospital; Grace Hospital, and Dearborn Veterans Hospital.

* References 6 and 7.

those 20 cases, 10 had obstruction and 5 had perforations and peritonitis. The very old appeared to be less sensitive and less alerted by the symptoms of serious disease.

In the charity group, 48% of the patients had had symptoms for more than one year. Thirty per cent had symptoms for less than three months and a few for only a few days. Almost without exception these patients had not been examined digitally or sigmoidoscopically prior to admission regardless of duration of symptoms. Over 40% of their lesions could have been reached by such examinations. Sixty-six per cent of this series had gross or occult blood in the

TABLE 1.—*Results in Treatment of Cancer Reported by Two Groups*

	Colcock [3]	Bleicher [4]
Resectability rate	90%	44%
Operative mortality	4%	29%
Five-year survival	60%	5.6%

TABLE 2.—*Management in 420 Cases*

	Consecutive Cases	Patients Operated Upon	Non-surgical Treatment
Receiving	71	60	11
Grace	147	127	20
Veterans	202	195	7

TABLE 3.—*Age Incidence by Decades*

Decade	Veterans	Private	Charity	%
10-19	0	0	2	0.05
20-29	8	2	1	2.6
30-39	17	3	4	5.1
40-49	14	25	14	12.6
50-59	86	39	12	32.6
60-69	56	49	18	29.2
70-85	21	29	20	16.6

stool, and one-third of the patients with lesions in the rectum and rectosigmoid had hemorrhoids. Two patients in this group had had hemorrhoidectomies in the recent past; two had appendectomies at which cecal lesions were missed, and four had exploratory laparotomies at which their lesions were not found.

For the group as a whole, there was over a 200% increase in the incidence of cancer of the large bowel between the fourth and fifth decade. It is therefore obvious that if early carcinoma is to be detected, every routine physical examination, particularly after the age of 40, should include a careful examination of the lower bowel by finger, scope, and x-ray. Irresponsible newspaper, radio, and television advertising of cures for bleeding piles and middle-aged constipation contribute to the further delay of adequate medical care. The operative mortality for the three groups is outlined in Table 4. In the private and charity

groups this varied from 20 to 25%. The veterans group had a lower operative mortality. This group was younger, and very few patients were admitted with obstruction and/or perforations. This observation will be discussed further.

We shall now consider the patients to whom only palliative surgery could be offered. Table 5 illustrates the cost to the patient of palliative surgery in terms of operative mortality.

In the private palliative group, when resection could be accomplished the operative mortality was only 13.3%. When colostomy alone could be done the mortality rose to 70%, and when only ileostomy could be done the mortality was 100%. Therefore the total operative mortality of 33.3% merely reflects the advanced stage of the disease and must be balanced against the palliation achieved. This is an accepted calculated responsibility. Of 26 patients who sur-

TABLE 4.—*Operative Mortality*

	Private	Charity	Veterans
Patients operated upon	127	60	195
Postoperative deaths	25	15	28
Operative mortality	19.7%	25%	14.3%

TABLE 5

	Private	Charity	Veterans
Number of patients	54	32	94
Operative deaths	18	10	20
Operative mortality	33.3%	31%	21.2%

TABLE 6.—*Curative Surgery*

	Private	Charity	Veterans
Number of patients	71	28	101
Operative deaths	7	5	8
Operative mortality	9.8%	21%	8%

vived palliative resection, three-fourths lived from 6 to 24 months in relative comfort. All were spared the distress of a local lesion and many the annoyance of a colostomy.

There is always the question whether the patient with cancer has metastasis and whether the surgery should be palliative or curative in scope. The surgeon can only estimate the significance of an opacity in the chest x-ray, an isolated nodule in the liver hidden from view, or an enlarged lymph node some distance from the primary lesion. But in 174 cases, both surgeon and pathologist felt there were reasonable grounds for hope. Those patients were subjected to what was considered curative surgery (Table 6).

The operative mortality in the three groups ranged from 8 to 21%. The private group mortality of 9.8% is acceptable. The marked contrast between the veterans and the charity groups reflects selection of patients in each instance, as the surgical staff in the two hospitals is almost identical. The patients at the charity hospital are the aged and debilitated with far-advanced disease. Also, the shortage of hospital

beds in the immediate postwar years forced many acute cases into charity hospitals, which thus presented a disproportionate number of difficult cases for management. In contrast, the veterans hospital patients were younger and usually came from distant sources. They had to be transportable to be admitted, and in many cases emergency surgery, with its attendant mortality, had already been done elsewhere.

Table 7 shows the disposition of 420 consecutive admissions for cancer of the large bowel in three hospitals in this area. There is a variation of 10% of presumably cured between the charity and the other two groups. Of these consecutive admission only 42% of the patients had successful resection with hope for cure; 36% were given palliation, while 21% died in the hospital with or without treatment.

We have followed 218 patients for five years. These comprise the private and charity groups and are listed in Table 8. In the private group 43.5% and in the char-

TABLE 7.—*Disposition of 420 Patients*

	Private	Charity	Veterans
Total patients	147	71	202
Presumably cured	43.5%	35.0%	46.0%
Palliated	34.0%	38.0%	36.6%
Hospital deaths	22.5%	27.0%	13.7%

TABLE 8.—*Five-Year Follow-Up of 218 Patients*

	Private	Charity	Total
Presumably cured	64 (43.5%)	25 (35%)	89
Known alive and well	21 (14%)	12 (16%)	33 (15.3%)
Not followed	11		

TABLE 9.—*Follow-Up of 202 Veterans Hospital Patients*

Presumably cured	93	46.0%
Known dead or dying	50	23.7%
Alive and apparently well	43	21.3%

ity group only 35% were presumed cured, yet the five-year survival rate in the two groups is practically the same. This fact illustrates the surgeon's difficulty in arriving at an accurate estimate of curability in cancer of the large bowel. Of 89 patients presumably cured, only 33, or 15.3%, were alive and well after five years.

The remaining 202 patients from the veterans hospital who were operated upon in the years 1948 through 1953 are listed in Table 9. The percentage presumably cured in this group is no better than in the groups operated upon five years earlier, a fact indicating that patients are not seeking care earlier in their disease. Of 93 patients presumably cured, only 43, or 20% of the total group, are now alive and apparently well. Since many of these patients have been followed only a short time, the future of this group appears no brighter than that of the private and charity groups.

Of the 218 consecutive admissions for cancer of the large bowel, 40% of the patients were discharged presumably cured, but only 15.3% were alive and well at the end of five years.

SUMMARY

Our study indicated that out of 100 admissions for cancer of the large bowel in this area, 40 patients will leave the hospital presumably cured but only 15 will be alive and well five years later.

DISCUSSION

DR. DUNCAN A. CAMERON, Detroit: As the co-author of this paper, with its dismaying results, I thought I should arise and assume partial responsibility.

It must be obvious to all of you that our patients came to us very late indeed. As we worked over this material we felt that undoubtedly irresponsible radio, newspaper, and television advertising of cures for bleeding piles, the glib making of a diagnosis of bleeding hemorrhoids over the drugstore counter by the druggist, the making of a diagnosis which we make only by exclusion, were factors in bringing the patients to us so late. We feel that these factors, to some extent at least, must be a responsibility of the medical profession.

What we are sure is a responsibility of the medical profession is the fact that so many of the patients had been seen by not only one but several physicians before the hospital admission which made them statistics in our paper, and almost invariabily the patients were not even undressed. Consequently, whatever teaching methods we have used in the past to try to impress upon undergraduate and graduate students the necessity for digital, proctoscopic, and sigmoidoscopic examinations have proved inadequate, and some fresh approach should be sought.

DR. DON W. MCLEAN, Detroit: We realize that the results we have reported must be disappointing to many of you. However, we believe that when there is no selection of cases and when only those cases known to be well are reported in percentages of the total group, including those that could not be followed, the final results will be about as we have found them in this series.

There is always a question as to the proper method of reporting cases that could not be followed. Excluding them introduces an element of selection, while placing them in a favorable category consitutes a report of hope rather than fact. Counting all unfollowed cases as dead or dying may not be entirely accurate. It imposes a penalty on an incomplete report and should serve as a stimulus to a better follow-up study of cases.

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ABSORPTION OF FAT IN THE ABSENCE OF BOTH BILE AND PANCREATIC JUICE

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ALTHOUGH a great amount of experimental work has been carried out in the past 70 years, considerable confusion exists in the study of fat absorption. The importance of bile and pancreatic juice in fat absorption has long been realized, yet their exact modes of action in this process are not fully understood.

Recently, Pessoa and associates,[1] in an attempt to clear some of the existing confusion, showed that in the absence of bile or pancreatic juice, fair amounts of fat are still absorbed from the intestine, and suggested the existence of some kind of fat-absorption mechanisms independent of bile or pancreatic juice in the intestine. They have not, however, determined whether in the absence of one (bile or pancreatic juice) the other is solely responsible for the amount of fat absorbed or whether some other mechanism independent of both bile and pancreatic juice exists for the absorption of fat.

The present study was therefore undertaken to answer this question.

METHOD

Male albino rats of Sprague-Dawley strain, weighing from 200 to 350 gm., were used.

Since Bloom and his associates[2] showed that the major portion of the long-chain fatty acid (palmitic) or its ester, fed to rats, is recovered in the intestinal lymph of the animals, it has become possible to use rats with intestinal lymph fistulas for studies on the absorption of fat. Therefore, cannulation of the intestinal lymphatic vessels was carried out in all the rats by the technique described previously.[3]

Six groups of rats were prepared for this experiment, as shown in Table 1. The first characters C, B, and D designate the group and indicate control (normal) rats, rats with biliary fistulas, and rats cannulized for duodenal drainage, respectively.

In the creation of biliary fistulas in rats, a fine polyethylene tube was inserted into the common bile duct at a level close to the liver so as to allow pancreatic secretion to proceed into the duodenum intact.

In the preparation of rats for duodenal drainage, a large polyvinyl tube was inserted into the lower portion of the duodenum so as to drain bile, pancreatic, upper duodenal, and gastric juice to the exterior. This procedure was necessary to ensure the complete absence of bile and pancreatic juice from the intestinal lumen below the lower portion of the duodenum.

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Recently, Edwards and Garber [11] reported that simple ligation and severance of the common bile duct close to the duodenum failed to exclude the pancreatic juice from the intestine in as many as half of their rats.

The second characters (S and D), designating the groups of rats in Table 1, indicate the sites (stomach or duodenum) of insertion of fine polyvinyl tubes to supply a 10% solution of dextrose in isotonic sodium chloride solution or various test fats.

Strictly speaking, it is rather difficult to obtain an ideal control group for comparisons in this experiment because after the creation of gastric fistulas, loss of acid alone would cause alkalosis. On the other hand, it has not been reported that the gastric juice plays a significant part in the absorption of fat. Therefore, we felt justified in using Group C (normal) and B (biliary fistulas) rats for comparative purposes.

After operation, rats were confined in restricted cages, and 5 to 10 hours later continuous collection of lymph was started to establish control flow and its fat content. After this period, fats were introduced into the duodenum or stomach, depending on the site of insertion of the tube. In the majority of cases, several tests were carried out in each rat over a period of four to five days. In a few cases absorption of fat was not complete within 24 hours after introduction of test fat, as judged by the turbidity of the lymph. In such cases, only the first 24-hour samples were used for analysis, and the second 24-hour samples were discarded.

TABLE 1.—*Preparation of Rats (Mechanism of Feeding and Explanation of Symbols)*

Preparation	Group	Bile	Pancreatic Juice
Fed fat-free diet by stomach tube; 0.4% NaCl solution ad libidum	C (control)	Present	Present
55 cc. of 10% dextrose in saline solution per day introduced			
Into duodenum	CD (control)	Present	Present
Into stomach	CS (control)	Present	Present
Into duodenum	BD (biliary fistula)	Absent	Present
Into stomach	BS (biliary fistula)	Absent	Present
Into duodenum	DD (duodenal drainage)	Absent	Absent

In the chemical analysis of the lymph, total fatty acids were estimated by a titrimetric method described by Hunter and associates,[4] lipid phosphorus by the method of Fiske and Subbarow,[5] and total cholesterol by the Kingsley-Schaffert method.[6]

RESULTS

All the results are shown in Table 2.

Fat-Free Period.—Part *a* of Table 2 shows the results obtained during the fat-free diet period. Remarkable uniformity of lymph flow and fat content was well illustrated in normal groups (C, CD, and CS).

Members of Group C were fed by stomach tube a fat-free diet which consisted of water-soluble egg albumin, dextrose, salt mixture, vitamin mixture, and Cellu-flour (nonnutritive cellulose) for three to five days. Daily samples were measured and chemically analyzed for fat content, and the results were averaged. The daily variation of lymph volume and total fat content was very small, for drinking water in the form of an 0.4% salt solution was freely accessible to this group of rats.

Members of Groups CD and CS received only 55 cc. of a 10% solution of dextrose in saline per day through duodenal or stomach tube by a constant infusion apparatus. Data assembled concerning these two groups are all from the first

24-hour samples after operation, yet the values for the groups are practically the same as values obtained in Group C. Lymph volume in the rats with biliary fistulas (BD, BS) and in those prepared for duodenal drainage (DD) were much lower than those in the control groups; the differences were well accounted for by the amount of fluid loss through the biliary fistulas or by duodenal drainage. The mean daily flow of bile was 14.9 cc. per rat (average of nine rats selected at random in B groups), and the mean volume of the fluid, collected by duodenal drainage was 28.3 cc. per rat per day (average of five rats selected at random in the D group).

TABLE 2.—*Fat Content and Volume of Intestinal Lymph per 24 Hours (Fat-Free and Fatty Diets)*

	Group	Weight Average, Gm.	Rats, No.	Lymph, Volume, Cc.	Total Fatty Acids, Mg.	Total Lipid Phosphorus, Mg.	Total Cholesterol, Mg.
(*a*)	Fat-Free						
	C	233	10	44.8 ± 3.4 *	117.8 ± 6.2	1.39 ± 0.05	12.8 ± 0.57
	CD	267	19	41.7 ± 2.6	108.6 ± 6.0	1.39 ± 0.09	11.6 ± 1.05
	CS	266	15	42.1 ± 2.5	118.1 ± 7.1	1.51 ± 0.08	12.4 ± 0.74
	BD	275	6	23.1 ± 3.9	8.5 ± 1.7	0.22 ± 0.04	3.1
	BS	275	15	29.5 ± 2.8	6.2 ± 0.56	.....	.....
	DD	271	40	17.8 ± 1.5	8.0 ± 0.57	0.21 (20) †	3.1 (10) †
(*b*)	Corn Oil (0.6 Cc. per Rat)						
	CD	250	8	42.1 ± 5.5	321.3 ±38.2	2.11 ± 0.14	14.5 (6) †
	CS	265	9	39.2 ± 3.9	447 ±30.6	2.70 ± 0.17	14.2 ± 1.1
	BD	320	5	36.8 ± 4.9	165.6 ±16.8	1.08 ± 0.16	7.5 3)†
	BS	272	7	30.0 ± 2.2	55.3 ± 6.4	0.51 ± 0.09	2.7 (6)†
	DD	266	11	16.2 ± 2.6	7.6 ± 1.6	0.22 (2) †	1.8 (1) †
(*c*)	Corn Oil-Fatty Acid (0.55 Cc. per Rat)						
	CD	264	6	39.7 ± 4.9	219.5 ±11.1	2.07 ± 0.25	13.2 ± 1.5
	CS	264	7	42.7 ± 3.9	455.1 ±37.5	3.06 ± 0.19	16.7 ± 0.99
	BS	280	6	25.3 ± 3.7	128.2 ±42.9	1.11 ± 0.10	5.3 (5) †
	DD	263	11	11.8 ± 1.8	29.7 ± 5.3	.....	.....
(*d*)	Oleic Acid (0.55 Cc. per Rat)						
	CD	271	7	43.4 ± 2.8	194 ± 8.6	2.19 ± 0.19	12.4 ± 1.4
	CS	260	6	44.9 ± 4.2	398 ±44.4	2.78 ± 0.24	14.4 ± 0.72
	BS	261	4	25.6 ± 7.5	165 ±55.4	1.69 (3) †	6.4 (3) †
	DD	279	6	15.4 ± 1.3	39.6 ± 8.1	0.34 ± 0.02	2.7 (5) †

* Standard error of the mean.
† Samples were not all determined. Number indicates the number of samples determined.

The content of fat in the lymph of the groups lacking bile (BD, BS, and DD) shows a marked decrease. Samples of lymph from these groups were water-clear, whereas samples from normal groups were always turbid. We expected the content of fat in lymph from rats with biliary fistulas (BD and BS) to be higher than that in lymph from rats of the DD group, but, as shown in Table 2, no significant differences were noted.

Corn Oil Period.—Part *b* in Table 2 shows the results obtained with corn oil. Since large quantities of fat are irritating to the intestine, corn oil was introduced in divided doses over a period of two to three hours into the duodenum (CD, BD, and DD). In Groups CS and BS, the entire dose was injected into the stomach at one time. However, the lymph of members of Group CD showed less fat than lymph from members of the CS group. But in rats with biliary fistulas more fat appeared in the lymph after corn oil was introduced into the duodenum than when

it was introduced into the stomach. The possible reasons for this will be discussed later. In rats with duodenal drainage (DD), the total fatty acid content of the lymph remained at about the same level after feeding corn oil as in the period on the fat-free diet, indicating that there was no absorption of corn oil in the absence of both bile and pancreatic juice.

Corn Oil-Fatty Acid Period.—Part *c* of Table 2 shows the results obtained with corn oil-fatty acid, a mixture of long-chain (C 16 above) fatty acids, the composition of which has been reported by Baldwin and Sniegowski.[7] It can be seen again in this Table that in normal rats the corn oil-fatty acid was not well absorbed when introduced into the duodenum (CS > CD). Lymph from rats with biliary fistulas (BS) showed considerable absorption of fat, and even the lymph from rats in the duodenal drainage group (DD) showed a detectable increase in fatty acid. The evidence presented here clearly demonstrates that there is some kind of mechanism for the absorption of free fatty acid via the intestinal lymphatics, entirely independent of both bile and pancreatic juice.

Oleic Acid Period.—Results obtained with oleic acid are essentially the same as those obtained with corn oil-fatty acid, as shown in part *d* of Table 2.

TABLE 3.—*Effect of No Fat and Various Fats on the Flow of Intestinal Lymph (Cubic Centimeters per Rat per Day)*

Rat, Type	No Fat	Corn Oil	Corn Oil-Fatty Acid	Oleic Acid
CD	41.7 ± 2.6 * (19) †	42.1 ± 5.5 (8) †	39.7 ± 4.9 (6) †	43.4 ± 2.8 (7) †
CS	42.1 ± 2.5 (15) †	39.2 ± 3.9 (9) †	42.7 ± 3.9 (7) †	44.9 ± 4.2 (6) †

* Standard error of the mean.
† Figures in parentheses indicate the number of rats tested.

Table 3 merely shows that the daily volume of intestinal lymph was not modified after feeding fat when a fixed quantity (55 cc. per day) of 10% dextrose in isotonic saline was given to the animal, although fat content of the lymph increased to three to four times that of the no-fat period.

COMMENT

Experimental Technique.—In the matter of intestinal lymphatic cannulation, Bloom and associates showed that between 70 and 80% of absorbed C^{14} palmitic acid was recovered from the intestinal lymph and suggested that collection of the intestinal lymph by the technique described by one of us (Bollman) and associates might not be complete. This suggestion was made on the assumption that all the absorbed palmitic acid is conveyed to the general circulation by lymphatic channels. This proposition appears to be correct, since more palmitic acid could be recovered in the lymph from the thoracic duct. More recent work with cholesterol [8] renders further support to this concept.

In this study we found that in normal rats (CS) approximately 67% (447 — 118 mg. = 329 mg.) of the fed corn oil (490 mg. of fatty acid eq.) was recovered in the intestinal lymph collected during the 24-hour period after feeding.

In this estimation we assumed that the endogenous fat in the lymph remained at the same level (118 mg.) during the absorption of fat, and for this reason we have subtracted 118 mg. (endogenous total fatty acid) from 447 mg. for estimation of the net absorption, 329 mg. Furthermore, if we assume that 90% of the corn oil fed ($490 \times 0.90 = 441$) was absorbed in a 24-hour period in our rats (CS), the recovery of corn oil in the intestinal lymph becomes about 75% ($329/441 \times 100$). This is in close agreement with the results of Bloom and associates.[2]

The foregoing argument, however, does not affect the usefulness of the particular technique for the collection of intestinal lymph for use in studies of fat absorption, because one can recover fairly constant fractions of the fat absorbed in the intestinal lymph thus collected. Because of the numerous anastomoses of the intestinal lymphatics, it is unlikely that all the intestinal lymph was obtained in our experiments. From all the factors concerned in our results, we would estimate that in these experiments approximately 80% of the intestinal lymph was obtained.

Chemical Technique.—The samples of lymph obtained from rats with biliary fistulas and from rats prepared for duodenal drainage during the fat-free period of diet were almost water-clear, with a very low content of fat. The titration values for fatty acid in these samples were so low as to arouse suspicion of the sensitivity of the method used. It was subsequently found that the analytic recovery of fat from these samples was as low as 60 to 70%. However, this titration method, described by Hunter and associates, was used throughout this study because it was adequate for the larger amounts of fat contained in normal lymph and for the amounts of fed fat absorbed. Therefore, the actual values of the endogenous fat (fatty acid) in lymph from rats with biliary fistulas and rats prepared for duodenal drainage may be 30 to 40% higher than the values shown in Part *a* of Table 2.

Endogenous Fat Content of Intestinal Lymph.—This term refers to the amount of lipids which are found in the intestinal lymph of an animal sustained on a fat-free diet or during fasting. Thus, the values for fat shown in Part *a* of Table 2 represent the endogenous fat in the intestinal lymph in a 24-hour period in normal rats (C, CD, CS), rats with biliary fistulas (BD, BS), and rats prepared for duodenal drainage (DD). Values for fatty acid in the intestinal lymph in rats of Groups BD, BS, and DD all are below 10 mg. per rat per day, whereas these values were well above 100 mg. per rat per day in normal rats (CD, CS).

These values are considerably lower than those reported by Borgström.[9] His values were 7.5 mg. per rat per hour for normal rats and 1.5 mg. per rat per hour for rats with biliary fistulas during fasting. These differences between Borgström's results and ours may be due to the different chemical techniques used to measure the fatty acids.

To explain the disappearance of the major portion of the fat from the intestinal lymph in rats of Groups B and DD, we have postulated the following equation:

$$\text{Endogenous lipid excreted by the gastrointestinal tract} = \text{endogenous fat in intestinal lymph} + \text{endogenous fecal fat} + x$$

X is an unknown factor, which may carry either a minus or a plus sign, depending on the degree of fat synthesis and also of fat utilization (destruction) by the intestinal flora, if there are any. The feasibility of this equation has been suggested recently by Pessoa and associates [1] and also by Borgström.[9] If it is assumed that

the excretion of endogenous lipid by the gastrointestinal tract and x are constant, the content of endogenous fat in intestinal lymph would be expected to decrease in the presence of a condition which causes an increase in the excretion of endogenous fecal fat. In fact, in the absence of bile or pancreatic juice, the excretion of endogenous fecal fat in dogs increases three to four times that of the control level (normal dog).[1] Therefore it is probable that the major portion of the lipids in intestinal lymph which disappear from rats with biliary fistulas and those prepared for duodenal drainage may be found in the feces, and that the endogenous lipid excreted into the gastrointestinal lumen undergoes the same process of digestion and absorption as dietary fat does. In other words, endogenous fat in intestinal lymph represents the reabsorbed portion of the endogenous lipid, and endogenous fecal fat represents the unabsorbed portion of the endogenous lipid excreted into the gastrointestinal lumen.

We expected the fat content of the lymph of rats in the B groups (BD, BS) to be higher than that of rats in the DD group because members of the B group should be able to reabsorb some of the endogenous fat excreted into the gastrointestinal lumen. However, we were not able to demonstrate any difference in the content of fat in lymph between the two groups. It may be that the conditions of our experiments did not provide adequate stimuli for pancreatic secretion, and perhaps pancreatic juice may not enter into the duodenum, thereby creating some condition analagous to that obtaining in rats prepared for duodenal drainage.

Absorption of Corn Oil (a Triglyceride; Part *b* of Table 2).—In normal rats, when corn oil was introduced into the stomach (CS), it was better absorbed than when it was introduced into the duodenum (CD). This, we believe, probably is due to the irritative action of corn oil on the duodenum, and it illustrates the importance of the reservoir function of the stomach in the absorption of fat. The work of Welbourn and associates,[10] in which they demonstrated that the absorption of fat is poor in totally gastrectomized dogs, is in accord with our view.

On the other hand, among rats with biliary fistulas, fat introduced into the duodenum was better absorbed than was fat introduced into the stomach. The reason for this difference in absorption among rats with biliary fistulas is not entirely clear. It may be speculated that a large amount of fat introduced directly into the duodenum might have been a better stimulus for pancreatic secretion than would be fat introduced into the stomach. In rats prepared for duodenal drainage, and in which fat was introduced into the duodenum, no increase in the total fatty-acid content was noted, indicating that there was no absorption of corn oil in the absence of both bile and pancreatic juice.

Absorption of Free Fatty Acids (Corn Oil-Fatty Acid and Oleic Acid).—As shown in Parts *c* and *d* of Table 2, free fatty acids were poorly absorbed when they were introduced into the duodenum (CD < CS). This is probably due to the fact that fatty acids are more irritating to the small intestine than are neutral fats. In rats with biliary fistulas (BS) the absorption of fatty acid was considerable. Even in rats prepared for duodenal drainage, in which fat was introduced into the duodenum, there was a detectable increase in the fatty-acid content of the lymph, which may be considered as credible evidence that fatty acids can be absorbed, to a certain extent, in the absence of both bile and pancreatic juice.

In this study we have presented evidence that in the rat intestine there exists a mechanism for the absorption of fatty acids independent of both bile and pancreatic juice. A triglyceride, corn oil, was found not to be absorbed in the absence of both bile and pancreatic juice. Observations, however, were made only on rats, with the use of a limited number of fats with low melting points. Therefore it would be desirable to accumulate more facts after the use of various other fats and other experimental animals before an attempt to arrive at a generalization concerning our findings.

Some remarks on the formation of intestinal lymph (Table 3) may be in order. It is usually thought that the absorption of fat causes an active flow of lymph from the small intestine. It was found in this study that such was not the case. As shown in Table 3, the absorption of fat did not modify the daily volume of intestinal lymph when a fixed quantity (55 cc. per day) of 10% solution of dextrose in saline was supplied to the animal. It appears that an increase in the fat content of lymph does not affect the tonicity of the lymph, since fats are present in the lymph in a form of large particles (chylomicrons). Any substances which are absorbed into the lymphatic vessels and at the same time contribute to the tonicity of the lymph possibly would increase the formation of lymph.

SUMMARY

The fat content of intestinal lymph was studied in normal rats, rats with biliary fistulas, and rats prepared for duodenal drainage.

It was found that the total content of fatty acids of the intestinal lymph in the absence of bile or in the absence of both bile and pancreatic juice was about 8 mg. per day per rat, that is, about 1/15 of that of normal intestinal lymph in animals sustained on a fat-free diet.

Corn oil was not absorbed in the absence of both bile and pancreatic juice, whereas its hydrolysate product, corn oil-fatty acids, and oleic acid were absorbed in small but macroscopically visible and chemically detectable quantities.

DISCUSSION

DR. JOHN H. GRINDLAY, Rochester, Minn.: I should like to ask Dr. Bollman whether giving a fat-free diet in disease when pancreatic secretion is not present in the intestine ever gives a fat-free stool in a patient, or whether he could continue to lose fat — endogenous fat — metabolic fat—that is ordinarily being absorbed in the lymphatics.

In the absence of pancreatic juice, it is not absorbed. Would that continue to be lost in the stool?

DR. J. L. BOLLMAN, Rochester, Minn.: In dogs in which the pancreatic juice has been prevented from entering the intestine, the fat content of the stools is about four times that of normal dogs on similar fat-free diets. Our data on rats are not entirely satisfactory because many of our pancreatic fistula-biliary fistula rats develop diarrhea, which complicates the picture. We are certain, however, that most endogenous fat which would appear in the intestinal lymph of normal rats is excreted in the feces. The fat-free diet does not prevent the loss of fecal fat.

I should like to point out again, however, that the addition of fat to the diet in the absence of pancreatic juice does increase considerably the amount of fat absorbed, even though more fat is lost in the feces. More phospholipid and cholesterol are formed by the intestine. These functions of the intestine are definitely more toward normal than in the absence of dietary fat.

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SKIN-LINED OMENTUM AND PLASTIC SPONGE TUBES FOR EXPERIMENTAL CHOLEDOCHODUODENOSTOMY

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STRICTURES of the common bile duct remain among the most perplexing problems confronting the surgeon. The history of one or more previous operations on the biliary tract in a patient who has jaundice, acholic stools, and dark urine is certainly one that will test the ingenuity of the surgeon at the time of operation.

The problem of reconstruction of the common bile duct to relieve the obstructive lesion and restore the patient to a normal physiologic state has stimulated numerous investigators to attempt a variety of methods of alleviating this situation.* McCorriston and MacKenzie [3] utilized split-thickness and full-thickness skin grafts in the form of tubes implanted in the omentum of rabbits and dogs. In one animal in each group, this tube was used to convey bile from the gall bladder to the proximal portion of the jejunum. These tubes did not prove successful. Hardin and Kittle [4] attempted to use free arterial and split-thickness skin grafts to bridge experimentally produced defects of the common bile duct in dogs; they concluded that these materials were not suitable for this purpose. Grindlay [5] employed polyethylene (Polythene) tubes to bridge the gap between the ends of defects in the common bile duct. There was no indication of obstruction at the end of one year.

PRESENT STUDY

Three groups of dogs were utilized in the present study. All procedures were performed under sterile conditions; each animal was anesthetized with ether, and an intratracheal tube was used. Cholecystectomy and production of an obstruction of the common bile duct were accomplished as a preliminary procedure in all dogs of the three groups studied. The obstruction was made by crushing the common bile duct forcibly with a forceps and then placing nonabsorbable ligatures on each side of the crushed segment. At the time of the initial operation, a split-thickness skin graft was removed from the left side of the abdominal wall with a dermatome. A tube was then constructed by suturing the autogenous graft around a Lucite rod 0.5 cm. in diameter, with the raw surface of the skin to the exterior. The covered rod was then implanted in the intact omentum and sutured into position (Fig. 1, *a* and *b*). Havens,[6] in 1939, conceived the idea of a skin-lined tube in the omentum and made such a tube in a dog. A report of this experimental work never was published.

Read at the 11th Annual Meeting of the Central Surgical Association, Detroit, Feb. 20, 1954.

From the Section of Surgery (Dr. ReMine) and the Section of Surgical Research (Dr. Grindlay) of the Mayo Clinic and Mayo Foundation. The Mayo Foundaton is a part of the Graduate School of the University of Minnesota.

* References 1 and 2.

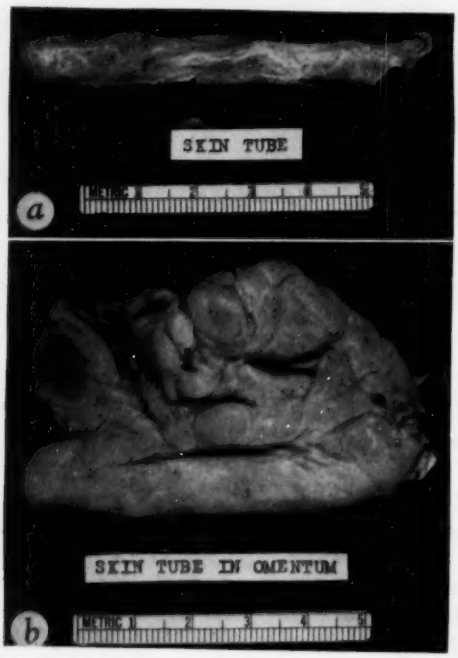

Fig. 1.—Tubes of skin: (*a*) sutured around Lucite rod; (*b*) buried in omentum.

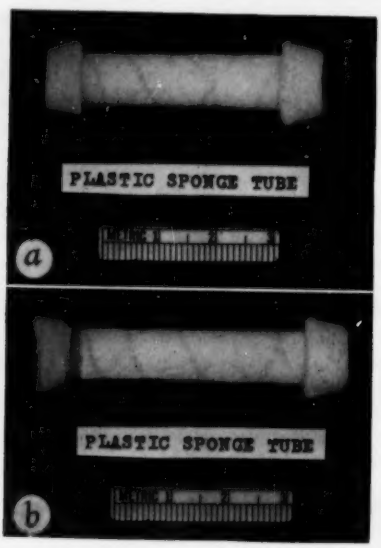

Fig. 2.—Plastic-sponge tube: (*a*) note cuffed ends; (*b*) note cuffed end unfolded.

The animals were operated on again after three to seven weeks. By this time, the dogs were noted to have clinical jaundice, acholic stools, bilirubinuria, anorexia, and loss of weight. The abdomen was entered through a right transthoracic, transdiaphragmatic approach.

In dogs of Group 1, the tube of skin was examined for viability and removed. Choledochoduodenostomy was then performed, with anastomosis of the common bile duct to the duodenum by the end-to-side method by means of two rows of interrupted No. 0000 silk sutures. Three dogs were treated in this manner for the purpose of comparing subsequent procedures with an accepted method of management of obstructions of the biliary tract.

In dogs of Group 2, the omental pedicle with its previously constructed autogenous cutaneous tube was swung into position to bridge the defect in the common bile duct. The Lucite rod was removed and the anastomosis accomplished with two rows of interrupted silk sutures. The stump of the common duct was sutured to the end of the tube of skin, and the other end of the skin-grafted tube was sutured to the duodenum. A segment of polyethylene tube 0.5 cm. in diameter was sutured into position to act as a stent for the anastomosis until the inherent tendency of the skin to contract had subsided. Failure to provide an adequate obturator for a sufficient

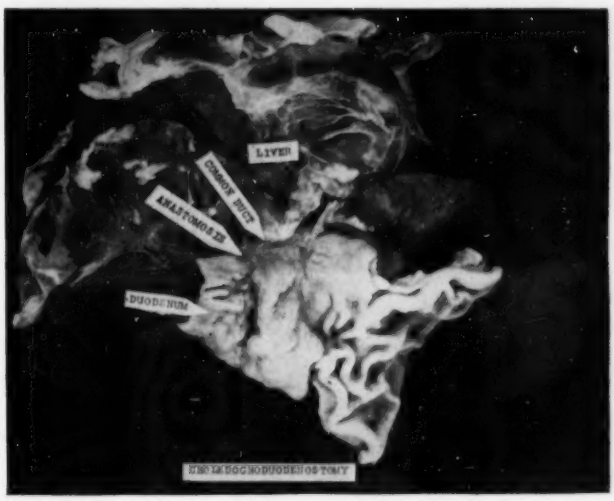

Fig. 3.—Formalinized specimen showing patent site of anastomosis after choledochoduodenostomy.

length of time may explain some of the failures of previously reported attempts to utilize skin. Six animals were prepared in this manner.

Seven dogs were utilized in Group 3. The tube of skin was removed from the abdomen, as in the animals of Group 1. A tube of polyvinyl-formal sponge † was sutured between the dilated obstructed common bile duct and the duodenum to reestablish biliary and intestinal continuity. These tubes † were 3 cm. in length and 0.5 cm. in internal diameter. The wall of the tube was made thin by compression and was rendered leakproof by impregnation with a boiling solution of gelatin. Until they were used, the tubes stood in formalin in order to keep them sterile and also to polymerize the gelatin and thus make it relatively insoluble. These tubes were constructed with cuffs at each end (Fig. 2*a*). The common bile duct was sutured to one end of the tube, and the duodenum was sutured to the other end. The cuffs at each end were then turned over the site of anastomosis (Fig. 2*b*) and sutured into position. The omentum was brought up and placed so that it completely surrounded the tube; it was then sutured into position to seal off the entire area. In early cases in which this method was employed, the tube

† Polyvinyl sponge (Surgical Ivalon Sponge) used in this study was furnished by the manufacturer, Ivano Inc., Chicago, and is available from Clay-Adams Inc., New York.

tended to kink and angulate, with partial to complete obstruction. This problem was remedied by again utilizing a polyethylene tube as a stent. This tube was later passed per rectum.

The animals in each of the groups were examined for evidence of recovery from the biliary obstruction. The sclerae were examined at regular intervals, the character of the stools was noted, and return of appetite and gain in weight were recorded.

One of each group of surviving dogs was killed under anesthesia from two to six months after relief of biliary obstruction. The remaining surviving dogs of each group were anesthetized and killed at various longer intervals. Two hours before they were killed, the dogs were given a meal of meat to which was added lampblack after the method of Musgrove and associates [8] to determine reflux up the biliary tree through the site of previous anastomosis. At necropsy, the stomach, duodenum, liver, bile ducts, and pancreas were removed en masse. The stomach, duodenum, and common bile duct were opened to examine the lines of anastomosis and the extent of reflux up the biliary tree. The specimens were then fixed in formalin and photographed. Tissue was removed from the common bile duct, the intrahepatic ducts, and the liver for histologic examination.

TABLE 1.—*Dogs Undergoing Choledochoduodenostomy (Group 1)*

	Common-Duct Obstruction and Cholecystectomy		Condition at Time of Reconstruction			Condition When Killed		
Dog	Date	Wt., Kg.	Wk. After Obstr.	Wt., Kg.	Jaundice	Wt., Kg.	Jaundice	Mo. After Obstr.
1	6/26/51	15.0	4	10.0	Severe	15.0	Absent	24
2	10/17/51	14.1	4	11.2	Moderate	15.5	Absent	6
3	5/ 4/51	17.2	7	9.5	Severe	18.2	Absent	25

TABLE 2.—*Dogs Undergoing Skin-Tube Reconstruction (Group 2)*

	Common-Duct Obstruction and Cholecystectomy		Condition at Time of Reconstruction			Condition When Killed		
Dog	Date	Wt., Kg.	Wk. After Obstr.	Wt., Kg.	Jaundice	Wt., Kg.	Jaundice	Mo. After Obstr.
4	8/24/51	15.3	4	11.0	Severe	18.5	Absent	24
5	10/31/51	18.5	4	17.5	Moderate	14.0	Absent	5
6	2/ 6/52	18.5	2	15.8	Moderate	16.6	Absent	3
7	2/ 8/52	19.5	3	19.0	Severe	20.0	Absent; dog died, liver abscess	7
8	2/ 1/52	18.4	2	17.3	Moderate	15.0	Absent; dog died, peritonitis	½
9	8/31/51	14.3	5	12.0	Severe	9.0	Present; dog died, common-duct obstr.	3

RESULTS

The animals in which the standard technique for choledochoduodenostomy had been utilized to reestablish biliary continuity remained well. These were killed at 6, 24, and 25 months after reconstruction (Table 1). All the animals had regained or exceeded their preoperative weights. No gross or microscopic evidence of hepatic damage was present. Gross examination disclosed reflux of the ingested lampblack up to the bifurcation of the hepatic ducts. The site of anastomosis averaged 0.75 cm. in diameter and appeared to be functioning perfectly, with no evidence of stricture or obstruction (Fig. 3). Ascites was absent in all these animals.

The animals in which a tube of skin was utilized for the common bile duct (Group 2) were examined at intervals varying from 2 weeks to 24 months (Table 2). There was reflux of lampblack approximately halfway up the common bile duct,

Fig. 4.—Specimen showing patent site of anastomosis after reconstruction utilizing skin-grafted tube.

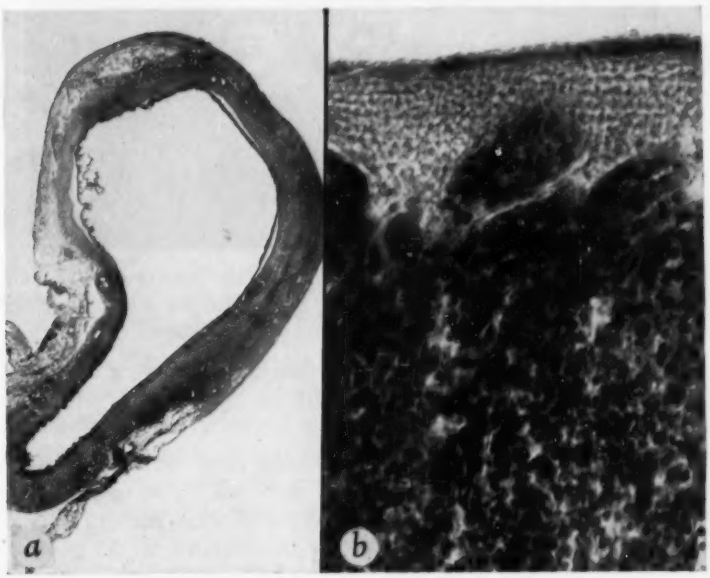

Fig. 5.—(*a*) Skin-lined common-duct tube showing separation of outer keratinized layers leaving soft smooth lining (hematoxylin and eosin; × 4); (*b*) portion of common-duct tube demonstrating appearance after outer layers have been passed (hematoxylin and eosin; × 225).

but none could be demonstrated in the biliary radicles with a hand lens. In this group, one animal died as the result of peritonitis and one died of hepatic abscess. Difficulty with obstruction of the common bile duct occurred in only one animal of this group; this dog died as the result of this obstruction. In the remaining animals the reconstruction functioned successfully, jaundice cleared, and the general condition returned to normal, with good appetite and gain in weight. No further evidence of stricture of the common bile duct was present. Necropsy disclosed no evidence of stricture of either anastomosis (Fig. 4). One animal was allowed to survive for 24 months after reconstruction. At the time of examination this dog had exceeded his original weight by 3.2 kg. and was free of jaundice and in apparent good health. Examination of the common bile duct showed the previously mentioned amount of biliary reflux; there was no narrowing of the common bile duct or distention of the biliary radicles. Function appeared to be normal. Microscopic examination was

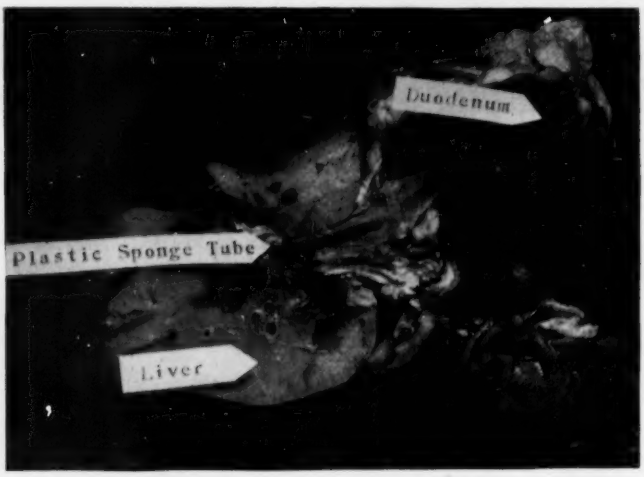

Fig. 6.—Specimen showing patent site of anastomosis after reconstruction utilizing plastic-sponge tube. Arrow labeled "Plastic Sponge Tube" indicates site at which this tube was used to produce junction between common bile duct and duodenum.

made of the tubes of skin to determine what changes might have taken place. It was found that the keratinized layer had separated, leaving a smooth velvety lining for the tube (Fig. 5).

The livers in the dogs in which plastic-sponge tubes were utilized (Group 3) appeared moderately normal grossly. In one specimen, an occasional area of focal necrosis was noted in the parenchyma on microscopic examination. Some evidence was present of reflux up the biliary tree, as demonstrated by the level of carbon two-thirds of the way up the common bile duct. The plastic-sponge tube had been passed. No photomicrographs were made in this instance, since the plastic-sponge tube had been passed and the stump of the common bile duct had grown to the duodenum. The omentum that had been wrapped previously around the tube, together with tissue that had formed around the plastic-sponge tube before its spontaneous passage, had produced a good junction between the common bile duct and

the duodenum (Fig. 6). Some contracture was present, but the stoma was not less than 0.25 cm. in diameter in any instance; this is approximately the size of a normal common bile duct in the dog. The weights of the dogs surviving this procedure returned to near normal or above the original preoperative value (Table 3). One animal of this group was allowed to live for 24 months; this dog weighed 2.8 kg. more than before operation.

COMMENT

Several inherent difficulties necessarily must be overcome in working with the skin of dogs. Extreme caution must be observed to obtain as clean an area of skin as possible for the construction of the intra-abdominal tubes. It is essential that tubular structures made of skin always be supported by an intraluminal obturator for three to six months to prevent the normal tendency to cicatricial stenosis.

TABLE 3.—*Dogs Undergoing Plastic-Tube Reconstruction (Group 3)*

	Common-Duct Obstruction and Cholecystectomy		Condition at Time of Reconstruction			Condition When Killed		
Dog	Date	Wt., Kg.	Wk. After Obstr.	Wt., Kg.	Jaundice	Wt., Kg.	Jaundice	Mo. After Obstr.
10	7/21/51	16.2	3	10.0	Moderate	19.0	Absent	24
11	1/31/52	14.5	2	13.8	Severe	15.8	Absent	4
12	2/11/52	17.4	3	16.5	Moderate	15.0	Absent	2
13	1/31/52	15.5	3	13.5	Moderate	12.5	Absent; dog died, peritonitis	2 days
14	10/17/51	14.7	4	10.1	Severe	8.0	Severe; dog died, hepatitis	2
15	8/24/51	19.3	4	13.0	Severe	10.2	Absent; dog died, intra-abdominal hemorrhage	3
16	8/31/51	16.8	3	12.0	Severe	8.0	Severe; dog died, hepatitis	3

SUMMARY AND CONCLUSIONS

Tubes made from autogenous skin grafts have functioned successfully in three dogs in restoring continuity between the common bile duct and the duodenum. Cuffed plastic-sponge tubes have bridged the gap successfully in three other animals. Three dogs have done well after choledochoduodenostomy.

Jaundice subsided and remained absent in all surviving animals of the three groups. Reflux up the biliary tree could be demonstrated in the animals from each group by the use of lampblack. The greatest extent of reflux was found in the animals in which choledochoduodenostomy was performed; in these animals, the reflux extended to the level of the union of the hepatic ducts. Gain and maintenance of weight after relief of obstruction to the biliary tract with clearance of jaundice were regarded as satisfactory.

Examination of the sites of anastomosis as long as two years after the use of tubes of skin and plastic-sponge tubes to bridge the gap between the stump of common duct and the duodenum revealed excellent function, with no evidence of stenosis or obstruction.

DISCUSSION

DR. STANLEY O. HOERR, Cleveland: I should like to ask Dr. Grindlay whether the tracts were studied histologically when the dog survived for 24 months.

Dr. Robin Anderson and I have been doing a similar procedure with dogs in our laboratory, employing a skin-lined tunnel in omentum to bridge a gap between the common duct and the duodenum. Several of our animals were killed at six or seven months, free from jaundice. The tract was patent, and grossly one would suppose it was lined with epithelium. Microscopic examination showed that the skin had faded away with the exception of one or two insignificant islands and that the lining was actually a type of granulation tissue. Whether this would ultimately have closed, as do other internal fistulae without an appropriate lining, I do not know. Our tunnel was smaller than that employed by Dr. Grindlay, and I feel he is correct in making these tubes large.

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EFFECT OF INCREASED HEPATIC BLOOD FLOW UPON LIVER REGENERATION

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CLINICAL emphasis following ligation and shunting of major portions of the hepatic blood supply has been chiefly directed toward the effect upon portal hypertension, with little regard for the consequences on liver parenchyma. That this is so is strange in view of the fact that numerous investigators * have shown that experimental hepatic regeneration is intimately linked with the portal blood traversing this organ. Practically all have demonstrated that partial hepatectomy and a diverting or decreasing of the portal blood flow by means of an Eck fistula, side-to-side portacaval anastomosis, or obstruction of the portal vein leads to an inhibition of the complete regeneration that is seen in normal animals. Little or no experimental evidence has been presented to denote whether it is quantity of portal blood, a qualitative factor of it, or a combination of the two that provides the impetus to liver restoration.

Only recently has it been demonstrated that perhaps portal blood in itself is not essential to regeneration, but that it is blood, per se, in the liver which is important. Grindlay and Bollman [6] constricted the inferior vena cava either above or below the liver in partially hepatectomized dogs with Eck fistulae or with partial porta vein occlusion and found that regeneration occurred. From this observation they postulated that "the liver needs to be well filled with venous blood for good regeneration to occur after partial hepatectomy and that . . . any procedure which will produce filling of the hepatic veins will favor regeneration of the liver." Childs and associates [7] determined regeneration in the partially hepatectomized dog following transposition of the vena cava and the portal vein. Normal control animals regenerated $75 \pm 27\%$ of their livers, and after transposition $50 \pm 21\%$ restoration occurred. In discussing their findings, they stated that ". . . systemic venous blood has been shown to be capable of supporting liver regeneration. . . . Since systemic venous

Dr. Bernard Fisher is a John and Mary Markle Scholar.

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From the Department of Surgery and the Addison H. Gibson Laboratory, University of Pittsburgh School of Medicine.

* References 1 to 5.

blood did not seem to be quite as effective as portal blood, the possibility of the existence of a portal factor of secondary importance cannot be unequivocally excluded."

The purpose of this paper is to report the effect produced upon liver regeneration in the partially hepatectomized dog when the portal blood flow is entirely deviated from the liver (Eck fistula) but is replaced by an increased amount of arterial blood traversing the hepatic portal circulation. In so far as could be ascertained, this is the first report on the effect of a sustained markedly increased hepatic blood flow upon liver regeneration.

METHOD

Mongrel dogs of both sexes, in apparent good health, weighing 5 to 15 kg., were used. They were separated at random into three groups and were subjected to the following procedures.

Operative.—All procedures were done with sterile technique, drop ether anesthesia being used. An endotracheal tube with cuff was inserted so that depth of anesthesia could be more readily controlled.

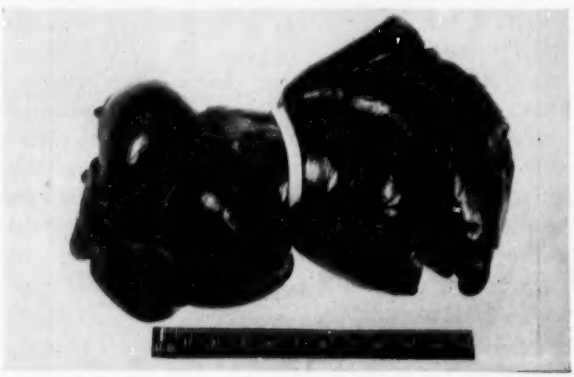

Fig. 1.—Forty-three per cent hepatectomy. White band denotes site of ligature. Entire left and left central lobes were removed.

GROUP I.—The abdomen was opened through a midline incision, and the stomach and intestines were retracted away from the liver. After the ligamentous attachments were freed, a ligature of No. 5 braided silk was tied securely around the pedicle of the left and left central lobes and these lobes were transected distal to the tie. Although the left central lobe does not have a true pedicle, a line of cleavage exists between it and the gall bladder lobe, so that the ligature may be drawn securely with no difficulty from bleeding. Extreme care was exercised so that the ligated stump was as small as possible. Resection of these two lobes (Fig. 1) in 15 animals killed immediately afterward for some other purpose revealed that they represent 42 ± 3.4% (Table 1) of the liver. All livers removed at operation and at autopsy in this and other groups were handled in the same fashion by the same person. They were immediately sliced into numerous pieces, blotted as free as possible from blood, and weighed, and an aliquot was taken for determination of the dry weight of the liver. Samples for histologic examination were placed in appropriate fixatives, and the rest of the liver was immediately deep-frozen in a sealed glass container. The rapidity with which this entire maneuver is performed is important to prevent drying of the liver. Thirty days after operation these animals were killed.

GROUP II.—In a one-stage operation, each animal of this group was first subjected to a partial hepatectomy in all respects similar to that in Group I and then to an end-to-side portacaval shunt (Eck fistula). The coronary vein, as well as other small branches going into

the portal vein, was ligated. This was done so as to completely prevent portal blood from entering the liver. A patent coronary vein in a partially hepatectomized animal with an Eck fistula has been seen by us in several instances to permit some liver restoration to occur. One month later, as in Group I, animals were killed.

GROUP III.—With a sweeping incision starting at the xiphoid, paralleling the right costal margin for about 2 in. (5 cm.) and then proceeding caudad, the abdomen was opened and a partial hepatectomy similar to that in Groups I and II was performed. The remaining portion of liver was then arterialized. This technique has been described elsewhere in detail.[8] It essentially consists of an end-to-side portacaval shunt and the interposing of a previously removed autogenous external jugular vein between the proximal cut end of the portal vein and the aorta just distal to the renal arteries. Since the external jugular vein of the dog has one and sometimes two sets of valves, it is imperative that the vein be positioned so as to permit blood to flow toward the liver. All vascular anastomoses were done with over-and-over continuous sutures of No. 00000 silk. Killing of these animals was likewise in 30 days.

Postoperatively all animals were placed on the usual stock diet consisting chiefly of "Friskies Meal." Although no exact measurement of food consumption was made, it was noted when animals failed to eat. Occasionally, for the first few days after operation, it was necessary to give an animal supplements of milk or syrup to encourage his taking of food. None of the animals reported were "noneaters," and food consumption was fairly uniform.

TABLE 1.—*Percentage of Liver Removed by Excision of Left Lateral and Left Central Lobes*

	Dog No.	Wt. (Kg.)	% Removed		Dog No.	Wt. (Kg.)	% Removed
1	643	7.4	44	9	683	9.3	44
2	658	12.3	44	10	682	12.0	43
3	654	19.9	48	11	695	9.8	40
4	659	9.8	40	12	652	17.0	41
5	647	16.3	47	13	698	8.7	42
6	655	8.7	49	14	642	13.5	40
7	650	5.7	40	15	663	15.64	42
8	670	9.2	38				
							42.8 ± S.D. 3.4

The percentage of liver moisture was determined by repeated weighings, until constant, of samples placed in an oven at 100 to 110 C. for 24 or more hours.

Liver protein nitrogen determinations were done on both wet and dry samples, the micro-Kjeldahl technique being used. Conversion of protein nitrogen to protein was made by multiplying the former by the conversion factor 6.25.

Liver regeneration was expressed (1) as per cent of the calculated liver weight at operation found at autopsy and (2) as the per cent of regeneration of the piece removed at operation (left and left central lobes). The latter was calculated from the formula: grams of increment (grams of liver at autopsy minus grams of calculated remnant at operation) divided by grams of liver removed at operation. The resultant figure, multiplied by 100, expressed regeneration as per cent. Thus, if the increment after death equalled the weight of the piece of liver removed at operation, 100% restoration had occurred and the total liver weight at necropsy would likewise equal 100% of the calculated liver weight at operation.

All values for estimated hepatic blood flow (EHBF) were obtained in the unanesthetized dog, the sulfobromophthalein (Bromosulphalein) method described by Bradley [9] being used. No. 6 ureteral catheters were inserted into the right jugular vein during local anesthesia and passed through the superior and inferior venae cavae into the hepatic vein under direct fluoroscopic visualization. After a priming dose of 2 mg./kg., sulfobromophthalein was given at a constant rate (1 to 1.5 mg./minute) with a constant infusion pump. Peripheral bloods were taken from a leg vein or, in some experiments, from a cannula previously inserted into a branch of the femoral artery. Detailed data regarding blood flow studies in the arterialized animal is to be presented elsewhere.

All livers removed at operation and autopsy were studied histologically by one of us. Thin slices from various areas were fixed in 10% formalin and on occasion in 95% alcohol and

Zenker's acetic fluid. After dehydration and paraffin embedding, sections were taken to water in the usual manner. The following staining procedures were performed according to the methods described in Lillie's "Histopathologic Technic"[10]:

1. Hematoxylin and eosin.
2. Masson trichrome method.
3. Oil red 0 on frozen sections of formalin-fixed tissue for lipid.
4. Periodic acid-Schiff procedure. These sections were compared with sections previously treated with barley malt diastase (0.1% in saline phosphate buffer of pH 6 for one hour at 37 C. and then stained with the periodic acid-Schiff method for the estimation of glycogen).

TABLE 2.—*Restoration of Liver Thirty Days After 43% Hepatectomy**

Dog No.	Body Weight, Kg.		Liver at Operation, Calculated				Liver Post Mortem			Original Liver, %	Regeneration, %
	Preop.	Post Mortem	Removed, Gm.	Remnant, Gm.	Total, Gm.	Water, %	Total, Gm.	Increment, Gm.	Water, %		
					I. Normal (7)						
411	8.6	....	102	135	237	71.0	204	69	75.8	86	68
431	13.9	13.5	194	258	452	68.5	311	53	72.6	69	27
498	12.7	12.4	170	226	396	69.5	391	165	68.0	99	97
669	8.7	9.5	99	131	230	71.0	278	147	73.0	121	148
710	8.5	8.2	85	113	198	72.9	170	57	72.5	85	67
727	10.9	9.8	134	178	312	75.0	295	117	74.0	94	87
744	7.9	7.9	94	125	219	71.5	187	62	72.4	85	66
	10 ± 2.3	10 ± 2.2	125	167	292	71.2 ± 2.0	262	96	72.6 ± 2.3	91 ± 16.0	80 ± 37.0
					II. Portacaval Shunt (5)						
553	8.3	6.0	98	130	228	74.0	119	—11	70.3	52	0
575	13.4	8.7	172	227	399	72.1	227	0	71.5	57	0
576	13.8	9.4	274	364	638	....	367	3	....	58	1
577	18.6	14.3	272	358	630	74.5	329	—29	72.2	52	0
725	10.8	8.8	123	163	286	73.8	123	—40	73.5	43	0
	13 ± 3.7	9 ± 3.0	188	248	436	73.6 ± 1.0	233	—16	71.8 ± 1.3	52 ± 5.9	0
					III. Arterialized (7)						
595	12.5	11.3	172	228	400	74.3	412	184	74.0	97	107
629	11.2	10.3	160	213	373	64.0	406	193	72.0	109	121
630	12.4	11.0	140	186	326	68.5	352	166	75.0	108	119
684	7.3	5.9	87	112	202	72.5	197	82	72.5	98	94
686	9.0	8.6	107	159	266	73.0	263	104	75.0	99	98
687	8.7	8.7	98	147	245	75.5	233	86	76.0	95	88
705	9.4	6.8	76	101	178	73.0	176	75	73.6	99	98
	10 ± 3.4	9 ± 2.0	120	164	284	73.1 ± 1.8	291	127	74.0 ± 1.4	101 ± 5.4	103 ± 12.5

* All figures represent the mean, except those after ±, which are the standard deviation of the mean.

RESULTS

GROUP I.—Seven animals were partially hepatectomized, and all survived in good health until they were killed. The average preoperative weight for the group was 10.2 ± 2.3 kg. and that at autopsy 10.2 ± 2.2 kg. At necropsy the livers were healthy, deep red in color, with rounding of the edges, typical of what has been described as the gross picture in regenerated liver. For this group, 91 ± 16% of the original liver was present, and 80 ± 37% restoration had occurred by 30 days after operation (Table 2). There was practically no difference in moisture content of the operative livers and the livers at autopsy, the former being 71.2 ± 2.0% and the latter 72.6 ± 2.3%. Microscopically, these livers revealed the usual centrolobular architecture. The hepatic cells showed moderately abundant stores of glycogen and lipid was scanty, a finding similar to that for healthy controls. The portal triads were not unusual.

Estimated hepatic blood flows were determined in three of the animals, Nos. 710, 727, and 744, just before they were killed and were 47, 79, and 72 ml./kg./minute, respectively.

Liver protein determinations on six animals in this group (Table 3) were made, and at operation there was found to be 14.49 ± 1.32% of protein. At autopsy there was 14.95 ± 1.82%. There was thus no significant difference in the amount of protein per gram of liver at operation and post mortem.

GROUP II.—Portacaval shunt and partial hepatectomy at the same time did not prove deleterious. Five animals operated upon survived the procedure and lived 30 days, until they were killed. All animals showed weight loss, the average preoperative weight being 13 ± 3.7 kg. and that at necropsy 9 ± 3.0 kg. All livers at autopsy were small, atrophic, and light tan in color, with sharp thin edges, in contrast to those in Group I. They represented 52 ± 5.9% of the original liver weight. Four of the five showed no regeneration. In three animals the liver was smaller than the calculated remnant at operation. One animal had 1% regeneration (Table 2). There was slightly less moisture in the liver at necropsy (71.8 ± 1.3%) than at operation (73.6 ± 1.6%). Microscopically, in many of the sections studied there was apparent "inversion" of the usual centrolobular architecture, with the

TABLE 3.—*Per Cent of Liver Protein at Operation and Post Mortem*

	Dogs	Protein	
		Operation %	Post Mortem %
Normal	6	14.49 ± 1.32	14.95 ± 1.82
Portacaval shunt	1	15.36	14.55
Arterialized	6	15.54 ± 0.85	16.13 ± 1.31

liver cords radiating about portal zones rather than central veins. This architectural configuration was similar to that recently described by Elias.[11] Many of the liver cells were vacuolated in paraffin section, and frozen sections stained by the oil red O method revealed abundant "sudanophilic" material. However, there was no evidence of fibrosis or periportal reactive changes. Glycogen content was scant to moderate. This fatty change (Fig. 2*A*) was quite striking when compared with the normal liver sections observed from the liver fragment obtained at the time of the operation.

Liver blood flow estimation was attempted in one dog in this series, No. 725, but it was virtually impossible to get adequate hepatic samples within a reasonable period of time because of the slow flow. This has likewise been a fairly constant observation in portacaval shunt animals when the entire liver is present. Liver protein was determined in only one animal in this group, No. 725 (Table 3), and there was a slight decrease in protein content, from 15.36% at operation to 14.55% at necropsy.

GROUP III.—Of 19 animals subjected to partial hepatectomy and arterialization as described, 7 died within the first 24 hours. All seven failed to awaken from the anesthetic, and all but one at autopsy were found to have several hundred milliliters of serosanguineous fluid in the peritoneal cavity. One had frank hemorrhage from the hepatic stump. Three died during the postoperative period, one each on the 4th

and 5th day, of massive hemorrhage when the graft separated from the aorta, and one on the 19th day, of what appeared to be overwhelming infection, with abscesses of the liver, peritoneal cavity, and abdominal wall. Two animals came to autopsy having complete obliteration of the graft lumen. In each, the aortic intima covered the operative aortic opening so completely that, except for bits of silk, it could not be found. These in effect were portacaval shunt animals. However, one (No. 690)

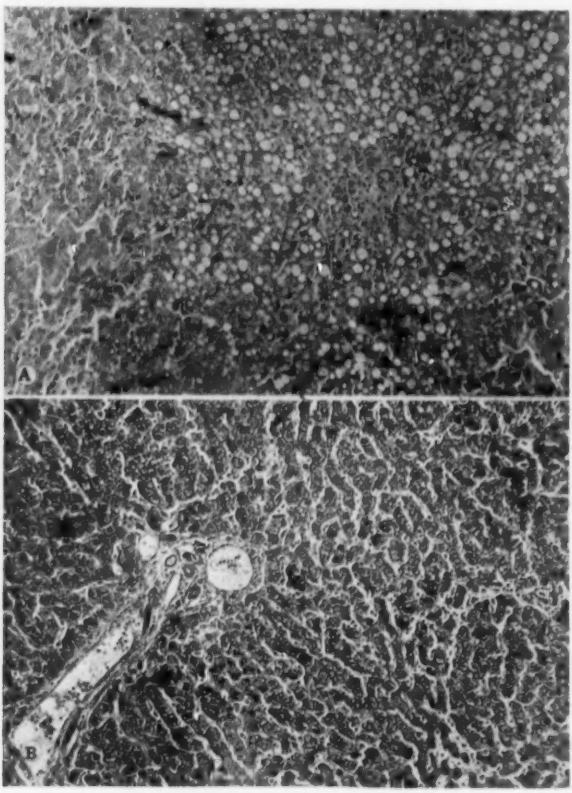

Fig. 2*A*.—After portacaval shunt. (Note increased amount of fat.)
Fig. 2*B*.—After arterialization.

showed 23.8% hepatic restoration, and the other (No. 609), 51.0% regeneration. Seven of the 19 survived in apparent good health, and at autopsy all demonstrated patient functioning grafts. Although weight loss for the group was slight, 10 ± 3.41 kg. preoperatively and 9 ± 2.0 kg. post mortem, it was not as pronounced as in the portacaval shunt animals.

The liver post mortem was 101 ± 5.4% of the original liver weight, with a regeneration of 103 ± 12.5% (Table 2). Per cent of liver moisture at partial hepatectomy was 73.1 ± 1.8 and at necropsy 74.0 ± 1.4.

Grossly, the livers at autopsy were slightly pinker than normal, and there was some rounding of the edges. After their removal, all observers were in agreement that they were firm in consistency upon being sectioned and that their appeared to be less blood oozing from the sections.

Microscopically (Fig. 2*B*), the usual centrolobular hepatic architecture was observed. The liver cells appeared to be of the usual size, and their nuclei were uniform, without degenerative or other change. The hepatic cells generally contained a moderate amount of glycogen. Lipid content was scanty, being no greater than that seen in healthy control animals. There was no sinusoidal congestion, and the portal triads were of their usual morphologic appearance. There was no evidence of vasculitis, either old or recent, within the hepatic branches of the arterial or venous channels.

Measurement of estimated hepatic blood flow was attempted in four of these animals, Nos. 684, 686, 687, and 705, just before they were killed. Only in No. 687 was a determination possible, this animal having an EHBF of 88 ml./kg./minute. In the others, although the catheters were well into the hepatic veins, samples were gotten with ease, and a peripheral level of 1 to 2 mg. of BSP was obtained, the hepatic vein, peripheral arterial difference in BSP concentration was small, or even in some instances equal, so that the Fick principle for calculation of blood flow could not be used.

Protein determinations on six animals (Table 3) from the sample removed at operation and at autopsy revealed a mean of $15.54 \pm 0.85\%$ protein at operation and $16.13 \pm 1.31\%$ protein at autopsy. The average total liver protein determined from the calculated liver weight at operation was 41.1 gm. and the liver weight at necropsy was 44 gm.

COMMENT

Under the conditions of these experiments it would seem that not only is portal blood totally unnecessary for regeneration but perhaps by increasing the volume and oxygen content of the blood flow to the liver there will result greater regeneration following partial hepatectomy than is seen in the animal with a normal hepatic vascular system (Fig. 3).

Instead of the commoner 70% removal, 43% hepatectomy was resorted to, because the former procedure combined with arterialization was practically incompatible with survival of the animal. Of 15 dogs subjected to arterialization and 70% hepatectomy, only 1 survived and had patent vascular anastomoses at the end of 30 days. Two others lived, but at autopsy the grafts were found to be fibrous cords, indicating that occlusion had probably taken place at or shortly after operation. Of the remaining 12, all died within 24 hours of operation. Of the latter, five had partial hepatectomy at the same time as arterialization and seven from two weeks to one month after. At necropsy all 12 animals showed patent anastomoses. The peritoneal cavities were filled with several hundred milliliters of serohemorrhagic fluid.

It is difficult to explain the extreme variability of regeneration in the normal control group. But this is in keeping with findings of others.[7] The animal with only 27% restoration, No. 431, was in good health when killed and had maintained his

preoperative weight. Dog No. 669, which regenerated 148% of his liver, gained more weight during the period of experimentation than any of the other animals observed.

Proof that the regenerated hepatic mass following arterialization and portacaval shunt is restored liver tissue may be obtained from several sources. The histologic examination reveals a normal quantity of glycogen within the liver cells. In no instance could one state that there was an increase in cell size because of glycogen deposition. Similarly, there has been observed no increase in cellular lipid beyond that which might be found in normal control animals. Sinusoidal congestion is not a feature. Further, vasculitis, as described by Cohn and associates,[12] was not observed in this short period of time (i. e., 30 days). The fact that there was no significant difference in the wet weights of liver samples at operation and at autopsy

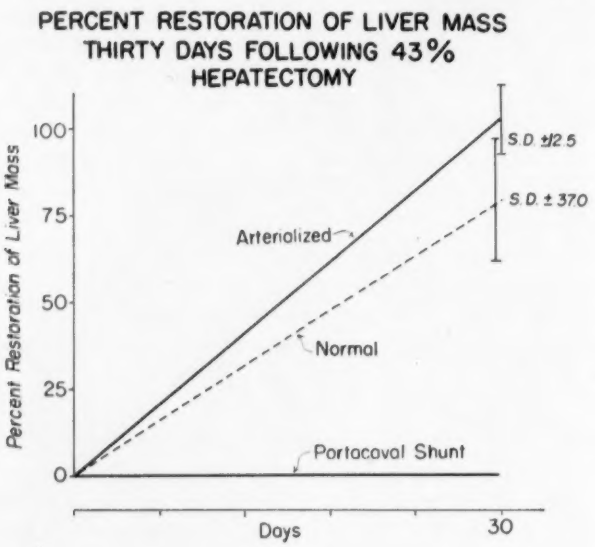

Figure 3.

strongly suggests that the increase in mass is not due to tissue edema or congestion with blood. Lipid analysis of all livers [13] suggests that after arterialization there may be a decrease in hepatic fat. The finding that there is actual liver protein restoration, as indicated by the similarity of per cent liver protein in the operative and postmortem samples, suggests a rapid deposition of new hepatic tissue. Lastly, the finding of regeneration (in one instance 50%) in animals which at autopsy showed complete obliteration of the graft, eliminates the possibility of excessive blood in the liver being responsible for the increase in mass. For, in effect, these were animals with portacaval shunts of probably about 10 days' duration whose livers partially regenerated before occlusion of the graft.

It would seem that limitations of the sulfobromophthalein method prevented the obtaining of estimated hepatic blood flow values for these arterialized dogs. This observation may indicate that the blood flow is too rapid to be determined by this procedure.

Observations in arterialized dogs without hepatectomy have revealed an EHBF of approximately 120 ml./kg./minute. Here, the differences in BSP concentration in peripheral and hepatic vein blood become so slight as to approach the realm of experimental error as set forth by Bradley; i. e., 10%. Thus, blood flows through these livers are probably greater than 120 ml./kg./minute.

It is of interest to note that among the normal partially hepatectomized animals two of three showed some elevation of blood flow determined just before they were killed (79 and 72 ml./kg./minute. In this laboratory we have found the EHBF in the unanesthetized normal animal to be 40 to 45 ml./kg./minute. Further observations on EHBF in the arterialized animal are being made.

Since regeneration did occur after substitution of arterial blood for portal blood, it is of interest to note whether this restitution was significantly greater than in the normal control group. With use of Fisher's t, a P value of 0.15 was obtained, this being above the range of probable significance, 0.01-0.05. However, if the one normal animal regenerating 148% of its liver, which would appear to be an unusual exception, is removed from the series, the P value becomes 0.08, which approaches probable significance. There were too few animals in both series for us to be absolute conclusive about the presence or absence of a difference, but from evaluation of the raw data, it would seem at least that regeneration of the liver is more apt to be increased by increasing its blood flow.

SUMMARY AND CONCLUSIONS

Groups of animals were subjected to (I) 43% hepatectomy; (II) 43% hepatectomy plus portacaval shunt, and (III) 43% hepatectomy, portacaval shunt, and arterialization of the liver remnant. At the end of 30 days, all animals were killed, and normal animals were found to regenerate $80 \pm 37\%$ of the liver, portacaval shunt animals 0%, and the arterialized group $103 \pm 12.5\%$. Histologic examination, wet and dry weight determinations, and tissue analyses for protein and lipid would all indicate that the increase in liver mass is due to the formation of new tissue. It is thus concluded that under the conditions of these experiments the normal dog liver will totally regenerate without portal blood, and it is highly suggestive that increase in hepatic blood flow will result in an augmented regeneration.

DISCUSSION

DR. SAMUEL P. HARBISON, Pittsburgh: It is always dangerous to transfer the results of animal experimentation into the human field, but I feel that this work by Dr. Fisher has thrown some light on certain clinical problems which we have been dealing with rather loosely. I refer to portal-systemic venous shunts and ligation of the hepatic artery for portal hypertension, the latter operation having been carried out by me in five instances with highly questionable results.

In any event, it seems inconceivable that by cutting down the blood supply to the liver we could expect anything except a moderate mechanical effect on the portal tension; and, perhaps more important, we are probably causing serious injury to the liver itself, as indicated in these experiments.

I am proud of Dr. Fisher's work in this field, and I should like to compliment him on his technique. This entire operation, consisting of a portacaval shunt, tranposition of a vein from the neck to connect the aorta to the distal portal vein, is carried out by him in about an hour's time.

DR. JACOB BERMAN, Indianapolis: This is an excellent presentation, and I realize the work that has gone into its preparation. I should like to ask one question: What is or will be the long-term effect in the experimental animal of such arterialization? This question is based upon three recent reports, as follows:

Rather and Cohn, who did the same experiment, found a necrotizing vasculitis throughout the liver when the high pressure from the aorta was directly shunted into the portal vein.

Schilling and McKee thought that shunts between the hepatic artery and the portal vein were innocuous, but after observing dogs for a period of three to five years they found that some of them died with massive ascites and others with liver necrosis.

Struckler, Lufkin, and Rice described a patient with a large fistula between the hepatic artery and the portal vein. This patient ultimately died with symptoms and signs of portal cirrhosis. I wonder whether Dr. Fisher observed similar changes in his dogs.

DR. BERNARD FISHER, Pittsburgh: I should like to thank both Drs. Harbison and Berman for their remarks. I hope that under no circumstances do I leave the impression that I think this procedure should be taken out of the experimental laboratory and moved elsewhere at this time.

Regarding vasculitis as described by Cohn, we have been particularly interested in looking for these lesions, and in animals which have survived as long as four months we have been unable in any circumstances to discover them; why, I do not know.

We became interested in the problem of arterialization of the liver not so much for the clinical implications, although we do keep these in the background of our minds, but because we feel that here is an opportunity to take an organ in the body, which is living under one type of environment, and to change that environment completely so far as the amount of blood and the amount of oxygen going to the liver are concerned. We should like to see what effect these factors have upon this organ.

Our studies are in progress to determine what the long-term effects will be in such respects as cardiac output, oxygen consumption, glucose metabolism, and cholesterol metabolism.

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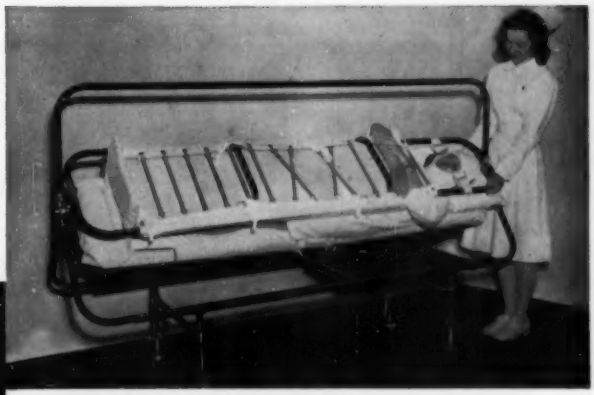

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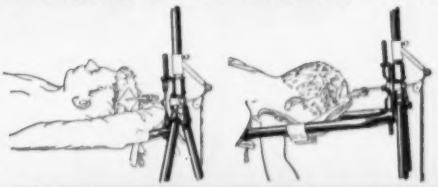

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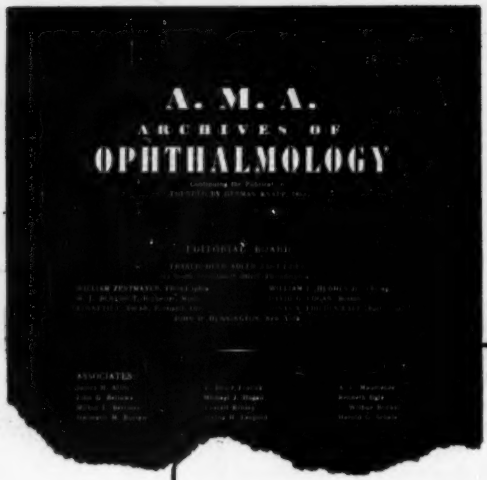

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